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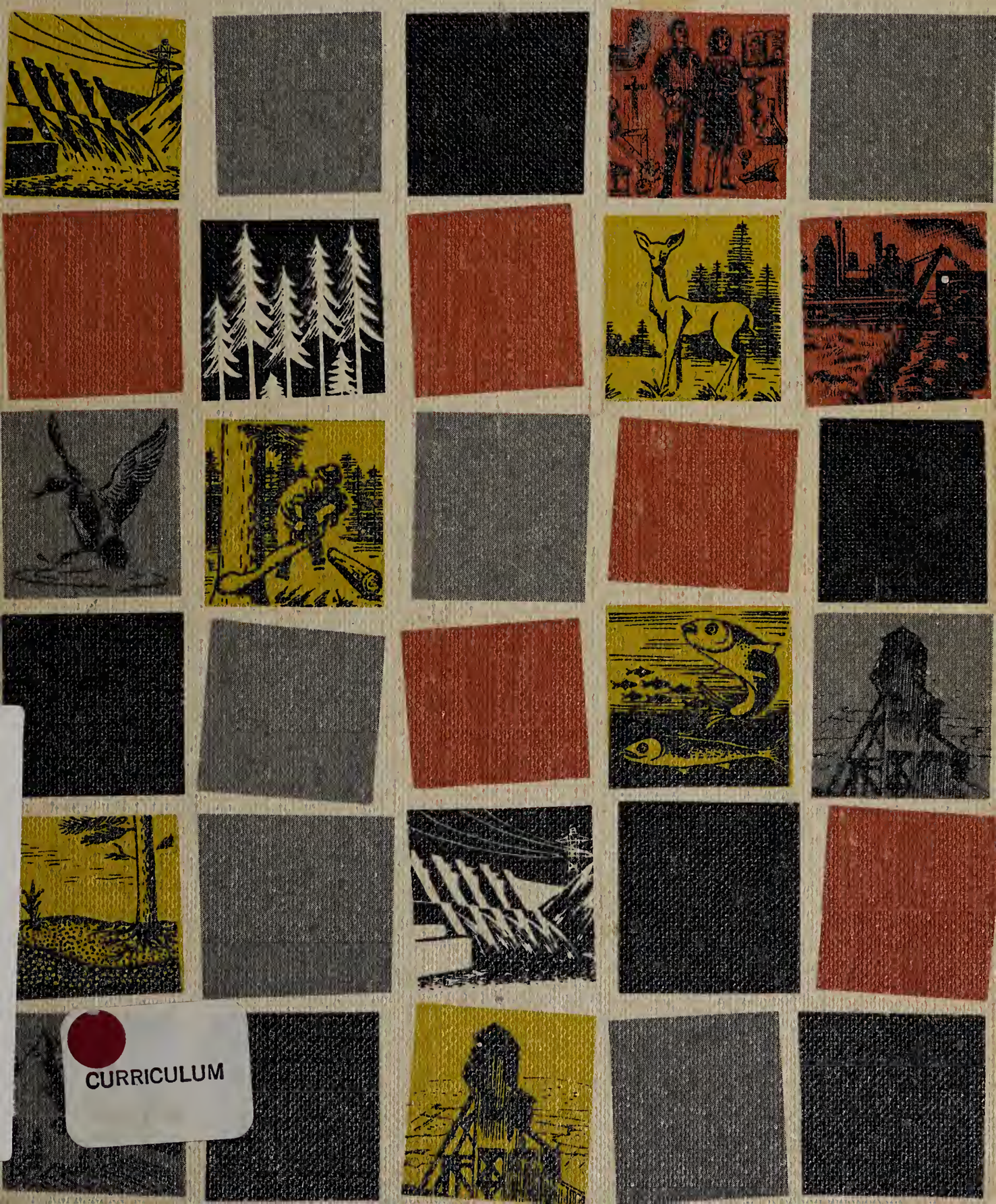
JAMES SAVAGE



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RESOURCES FOR TOMORROW

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RESOURCES FOR TOMORROW

MACMILLAN OF CANADA

TORONTO

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Preface

The wealth of a nation lies in its natural resources and in the character and ability of its people. Canada is a country richly endowed by nature, and to the wealth obtained from the abundance and diversity of its resources is added the strength and vigour derived from the diversity of its people.

In climate and scenery as well as in resources, Canada is a country of variety and contrasts. Canada is the picturesque valley of the St. Lawrence, the oval hills and placid valleys of the Maritimes, and the rocky lakes and evergreens of the Canadian Shield. It is the golden ocean of the prairies rippled by a summer breeze and the snow-capped peaks of the Rockies reflected in the emerald waters of a glacial lake. It is the spray-drenched rocks of Newfoundland and the sheltered islands of the Strait of Georgia. It is a land of teeming cities and a land of arctic loneliness; a winter wonderland for skiers and a summer paradise for campers.

Canada is the mingling of lakes and forests, like glistening rain pools in beds of moss; it is the sudden melting of the snows in spring and the sound of water cascading down the hillside; it is the hammering of the woodpecker in the silent woods, and the eerie call of the loon over a moonlit lake.

This is Canada, a land of vast distances and a people who refused to let distance divide them; a land that has grown from a wilderness to a great nation by the toil, perseverence and imagination of its people; a land whose distances have been conquered, whose rivers have been harnessed, where oil-derricks stand among the wheat-fields and the headframes of mines project above the tree tops. It is a land whose future greatness is assured *if* we accept our responsibilities and stand on guard as trustees of tomorrow's resources.

J.S.

RESOURCES FOR TOMORROW

PART I: THE EARTH

1 The Beginning

Several scientific theories have been suggested for the earth's origin but none of them can provide answers for all the questions we might ask about this very ancient and important event.

Many modern astronomers and geologists believe that the earth began as a spinning globe of dust formed by the collision of innumerable tiny particles. As time went on, this ball-shaped "pile of rubble" grew, and as it grew, its gravitational force increased, so that many more particles were attracted to it and collided with it. Gravitational pressure, collision, friction, radioactivity, and heat from the sun all combined to raise the temperature of this primitive globe so that it melted and may even have become incandescent. Eventually the surface temperature must have dropped to the point where solidification began to take place, and the sphere acquired a solid crust. The rock that formed in this way is called *igneous* rock, from the Latin word *ignis,* a fire. At this

turbulent stage in its history the earth must have resembled a gigantic fiery furnace of partly solidified rock, bubbling and seething in a variety of fantastic shapes.

As the molten material cooled to form rock, various gases were given off, forming an atmosphere that consisted largely of water vapour, nitrogen and carbon dioxide. After a very long cooling-off period, temperatures lowered to the point at which water vapour condensed. Then clouds began to form, first like wisps and patches of fog and later in enormous dark banks that shrouded the earth and blotted out the sun. We can picture the first rainfall sizzling and hissing on the scorched rocks, turning back into steam, and repeating the process again and again. Never since has the earth seen such rain as fell in those ancient times, for we must remember that all the water that now makes up the oceans, lakes, rivers, and ice-caps was then in the form of clouds or steam.

At length, when the greater part of the earth was covered with water, the clouds began to disperse, and the cycle of condensation and evaporation slowed down to something like its present-day rate. It was then that the forces of erosion came into play. Wind, water, and ice ceaselessly attacked the igneous rock and carried the eroded particles to the river mouths to form bars and deltas, or out into the oceans, where they settled and hardened into layers of *sedimentary* rock.

Even after the crust had formed, the earth continued to be subjected to tremendous forces of contraction and expansion. As a result, great masses of the rocky surface were twisted and forced upward. In many cases sedimentary layers that had once formed the beds of oceans were elevated to form plateaus and mountain ranges. These newly-elevated rocks were again exposed to the wear and tear of wind and water, and new layers of sediment were formed in the oceans and lakes.

Since then great convulsions have taken place in the earth from time to time, and vast quantities of molten igneous rock have poured out from volcanoes, forming layers on top of the sedimentary rocks. You can see that the present structure of

the earth's crust is very complicated, but geologists, by painstaking work, have been able to piece together many of the parts of the puzzle and discover a great deal about the history of the earth.

In fairly recent times (as geologists think of time – that is, within the last million years) enormous ice-fields from the polar areas moved over Canada and even penetrated to some extent into the United States. This happened, not once, but several times. They are known as glacial periods, and the comparatively warm periods between them are called the *interglacial periods*. During the glacial periods great masses of ice, sometimes nearly two miles high, pushed irresistibly over the earth like enormous bulldozers; then they receded. But they did not *move* backwards; they simply melted back gradually as the climate became milder. The thousands of lakes and connecting waterways of northern Canada, and even the Great Lakes, are the result of glacial action. As the ice moved forward it carried a great quantity of soil and pulverized rock with it and deposited this far south of its origin. At the same time it gouged, eroded, and spattered with lakes the enormous area of igneous rock we call the Canadian Shield. This rugged area is now known to be one of the world's greatest storehouses of mineral wealth.

Not only have there been great ice ages in the past, but geologists have found evidence that warm, almost tropical, climates once existed even in the northern parts of Canada. It is known that corals can develop only in warm seas, yet oil drills in Alberta frequently pass through coral reefs. It is also known that our coal deposits were formed from luxuriant forests that could flourish only in a warm, moist climate.

The surface of the land as we now know it has been shaped by enormous forces of upheaval: by the invasion and withdrawal of oceans, by the irresistible sculpturing of the ice, by the deposition of rubble and boulders which the ice carried, and by the everlasting erosion of wind and water. Beneath the surface, in veins and pockets, lie great storehouses of minerals,

metals, coal, and oil deposited during the long, eventful period of the earth's history. It was the discovery and utilization of these minerals and fuels that made it possible for civilization to advance beyond the Stone Age.

QUESTIONS

1. Look up information on "The Collision Theory" of the earth's origin. This is the theory put forward by Jeans, Chamberlin, and Moulton. What was Laplace's theory of how the earth was formed?
2. Approximately what percentage of the earth's surface is covered by water? Where was this water when the surface of the earth was extremely hot?
3. To what temperature must the crust have cooled before the oceans began to form? Give the answer in both centigrade and Fahrenheit degrees.
4. What is the difference between igneous rock and sedimentary rock? Name at least three examples of each.
5. Describe the formation of sedimentary rock. What are fossils? In which type of rock would you expect to find fossils?
6. Make a collection of rocks, minerals, and fossils.
7. The peaks of some of the Rocky Mountains are made of sedimentary rocks and contain fossils of sea animals and plants. How can this be explained?
8. What is a glacier? Where do glaciers exist today? How do glaciers advance? How do they recede?
9. Where is the Canadian Shield? Outline it on a map of Canada. Describe its physical features and the rock of which it is composed.
10. What "ages" came after the Stone Age? In which "age" would you say we are now living? On what mineral, or minerals, does it depend?

PART I: THE EARTH

2 The Flood

AN INDIAN MYTH OF THE EARTH'S ORIGIN*

Long long ago all the north of this country was under ice, but when the ice melted there were great floods and the waters all swept down to the lands which were already inhabited by the Indians. Everybody was in danger and all and sundry were getting drowned when Iktoomi (a mythical deity) took pity on them and decided that he must save some people. He therefore saved one man and one woman, and one male and one female of each kind of animal. He built a large raft and he put them all on it and they all floated about on the flood waters.

After seven days, however, Iktoomi went to the beaver and he told the beaver that he must try and dive right to the bottom, under the flood waters, and see if he could bring up a

* This story is one of the legends of the Plains Indians of the Stoney or Assiniboine tribes. It was reported by Dr. Elizabeth Cass of the Indian Health Services, and is reprinted from "The Beaver", March 1962, published by the Hudson's Bay Company and reprinted with permission.

piece of dirt. The poor beaver dived and dived but he never could reach the bottom, and he never could find the piece of dirt. So Iktoomi told him to rest, and the next day Iktoomi took hold of the muskrat and he said to him: "You try and see if you can bring me up a piece of mud." Well, the little muskrat dived very deep and he didn't come up. They all got very worried and they waited and waited. About five hours later the inert body of the muskrat floated to the surface of the water near the raft. Iktoomi took it on the raft and found in the muskrat's paw a little mound of mud. Iktoomi revived the rat and he took this little bit of mud and he moulded it with his fingers, and as he moulded it, the mud grew and grew. Finally he put it over the side of the raft and it went on growing into solid land so that soon he could land from the raft with all the animals. And the land still went on growing and growing from where he had moulded it.

When all the animals were ashore and the land was still growing, he waited till the edge was out of sight and then he got hold of the wolf, and he told the wolf to run round the earth and only to come back and tell him when the earth was big enough to hold a large population. Meanwhile he assembled all the animals (and the man and the woman) in a circle and he sang them spirit songs and made them dance the first Sun Dance.

Now the wolf took seven years on his journey but he couldn't quite complete his tour of the world. He crept back home exhausted at Iktoomi's feet. Iktoomi then told the little raven to go out and see if he could complete the bit of the world that the wolf had not seen. Now the raven in those days was quite white, and he flew off to do Iktoomi's bidding. But instead of flying as he was told to do, he got hungry, and seeing a corpse floating by he flew down and began to pick at it. Then he flew home again, and when Iktoomi saw him he knew that he had been eating a dead body, for his beak was full of blood. So he seized hold of him and said to him: "Since you have such a dirty nature, you shall have a dirty colour."

The raven was turned from white to black and that colour he remains to this day.

Now during this time, when they were dancing the Sun Dance, all the animals and man were friendly and Iktoomi could speak to all of them in their languages and they all could converse with each other. When the raven came back and was turned black, Iktoomi told them all to go into the world and prosper and multiply, and left them.

PART I: THE EARTH

3 Minerals and History

Until the present century minerals were not considered very important natural resources in Canada. Fish, furs, timber, and wheat were the greatest sources of money and employment. It is true that mining was carried on as far back as 1720, when the coal seams at Sydney, Nova Scotia, were first worked, but Canadian mining as a great industry is a child of the twentieth century.

The discovery of minerals and the development of the mining industry is one of the most fascinating chapters in Canadian history. Following the great California gold rush of 1849, prospectors gradually worked their way northward into western Canada. In 1858 gold was found along the Fraser River and its tributaries, and later some of the richest placer deposits in the world were discovered in the Cariboo country. The Cariboo gold rush was responsible for the building of the first highway in western Canada, the Cariboo Road, which followed the canyons of the Fraser and Thompson rivers north-

ward to Barkerville, the centre of the Cariboo mining fields. Barkerville was named after Billy Barker, a famous prospector who made and lost a great fortune in gold. In 1864 Barkerville was the largest town west of Toronto and north of San Francisco.

The discovery of gold attracted a great many people to the region that was to become British Columbia, with the consequent exploration and opening up of the country. Following the gold discoveries a great variety of other enterprises began and the foundations of ranching, farming, and fruit-growing were laid. Later the great mining area of the Kootenays was discovered, with its lead, silver, zinc, coal, and many other minerals of great value. As a result of these events, the importance of the region became so great that the eastern colonies undertook to build a railway linking up the east and west. In fact the building of a transcontinental railway was one of the conditions for the entry of British Columbia into the Canadian Confederation.

The Canadian Pacific Railway Company was incorporated at this time and was entrusted with the contract to build the railway across the continent. Thus the discovery of gold in the Cariboo region was a vital factor in the establishment of Canada as a nation united from sea to sea.

The rocky, lake-splattered country of the Canadian Shield, extending from the Ottawa River to the prairies, interposed a formidable barrier to the railway builders. However, the conquest of this barrier and the disclosure of the wealth it contained turned out to be one of the greatest events in modern times, and contributed greatly to the growth of Canada to its present position as one of the most favoured nations of the world.

The first great discovery was made at Sudbury in 1883 when Tom Flanagan, a blacksmith with a construction gang, noticed a ridge of mineralized rock. He collected some samples but apparently made no attempt to profit from his discovery. Soon after this the Murray brothers from Pembroke became

interested in the mineral and purchased the land from the government. Even they were unable to develop it and it changed hands several times before a profitable method was devised for the mining and smelting of the copper-nickel ores.

The Sudbury basin today is the source of most of the world's nickel and platinum, and of about half the copper produced in Canada. One of the great mines is called the Murray Mine. It produces millions of dollars' worth of ore annually and is located on land that the Murray brothers purchased for a dollar an acre.

Shortly after the discovery of mineral wealth in the Canadian Shield another great gold strike was made in the west, this time in the Yukon. In 1896 rich deposits of gold dust were discovered at Bonanza Creek, a tributary of the Klondike River. The following year over two million dollars' worth of gold in dust and nuggets was recovered by the miners, and a small trading-centre called Dawson City was established. News of the strike caused little excitement in the outside world until the gold-rich miners landed at Seattle and San Francisco with tales of a land where gold could be scooped up by the handful.

Almost immediately the great Klondike Gold Rush began. People from all over North America – in fact from all over the world – flocked to the Pacific ports and tried to find passage to the Yukon. Most of the stampeders were landed at Skagway at the end of a long fiord. From here they had to struggle over mountain passes (Chilkoot Pass and White Pass) to reach the headwaters of the Yukon River. The account of the hardships endured by the stampeders and their adventures in the goldfields is one of the most colourful and exciting stories in the history of Canadian mining. The peak of gold production was reached in 1900, when over twenty-two million dollars' worth was found. At this time the population of Dawson City was about 30,000, but it soon began to decline as the richer and shallower gold diggings became exhausted.

The next great mining event takes us back to the Canadian

Shield and the discovery of silver at Cobalt, Ontario, in 1903. This discovery parallels in a remarkable way the discovery of nickel and copper at Sudbury. Both discoveries were accidental, both were made by men engaged in railway construction, and both were made by blacksmiths. The blacksmith in this case was Fred LaRose, a legendary figure in the history of Cobalt. The story is told that LaRose threw a heavy hammer at an inquisitive fox, missed the fox, but broke off a chunk of rock that revealed a glistening vein of silver.

Great fortunes were made and lost in the rush that followed, but more important than this, an adventurous mining spirit was created that led to the discovery and opening up of other mining centres. The wealth produced in these new camps – such as Timmins, Porcupine, and Kirkland Lake – financed further prospecting and set off a regular chain reaction of exploration and development that extended the length and breadth of Canada.

Since the beginning of the century Canada has forged ahead to lead the world in the production of asbestos, nickel, platinum, radium, and uranium. She has also reached second place in the production of copper, silver, and lead. Enormous reserves of petroleum and natural gas have been located in Alberta, and new discoveries in Quebec and Labrador indicate that Canada may soon supply most of the iron ore needed on this continent.

The discovery and utilization of our mineral wealth was, as we have seen, one of the most important factors in uniting our country at the time of Confederation. It has also been a vital factor in the growth of Canada from a colony to an independent nation with a position of importance among the nations of the world. Although our population has trebled in the last fifty years, we have been able to maintain one of the highest standards of living anywhere in the world.

There are many ways in which mining has contributed to the growth and prosperity of Canada. It has been responsible

for the continual expansion of our frontiers and the development of a great many new communities with their connecting links of roads and railways. It is also of great importance because of the number of people employed. The mines and mining industries support over half a million people directly; these people spend about seventy million dollars each year for food and a hundred and fifty million dollars for clothing, houses, cars, furniture and other items. Besides this, the mining companies purchase annually about a hundred million dollars' worth of lumber, machinery, and other supplies; all this spending provides employment and wages for many more people.

Mining has brought us new wealth from all parts of the world – money to be invested in mining and money to pay for the minerals that have been exported. In the past fifty years Canada has produced minerals worth over ten billion dollars, and our present operations are adding to this at the rate of about one billion dollars per year.

We must not look upon our mineral resources as something we are entitled to squander. It is the duty of the Canadian people, as trustees of this enormous wealth, to use it in the wisest and most efficient way and to see that it is used, not only for the welfare of Canada, but for the advancement of the whole human race. This means that we must *conserve* our mineral resources, for the word *conserve* does not mean to hoard but to *use wisely*. Canada's vast potential of forests, water power, and underground minerals and fuels should, in view of the approaching exhaustion of the natural resources of older lands, enable this country to play a very important part in the world economy.

In dealing with resources it is customary to distinguish between those that are renewable and those that are non-renewable. Renewable natural resources are those that can be consumed and then replaced again and again, such as farm crops and forests. Our mineral resources are obviously non-renewable, making it all the more important that they be wisely used.

QUESTIONS

1. Name an important mining event associated with each of the following dates: 1720, 1849, 1883, 1903.
2. On a map of British Columbia locate (i) The Cariboo Range, (ii) Barkerville, (iii) The Kootenay Range.
3. State an interesting fact about each of the following: Billy Barker, Tom Flanagan, Fred LaRose.
4. The invention of dynamite was announced by Alfred Nobel in 1867. What important event in Canadian history took place in that year? How did Nobel's invention contribute to the growth of Canada?
5. What circumstances led to the building of the transcontinental railway in Canada? Who was the Prime Minister at this time? When and where was the last spike driven?
6. What words are written on the Canadian Coat of Arms? What do they mean?
7. On a map of the Yukon locate Dawson City and the Klondike River. Trace out the route of the stampeders from Skagway to Dawson.
8. Read some of the poems in *Songs of a Sourdough* by Robert W. Service.
9. What metal besides silver is found at Cobalt? What are some of its uses? What is a "cobalt bomb"? How is it used?
10. Describe four ways in which mining has contributed to the growth and prosperity of Canada.
11. What do we mean by the word *conserve*? What is the difference between renewable and non-renewable natural resources?

PART I: THE EARTH

4 Discovery

Patrick Morgan stood looking out the rain-streaked window at the glistening steel rails that passed a few feet from the door of his log-cabin office. In one corner of the room stood his "desk" made of three heavy planks supported by empty dynamite kegs. Above the desk a calendar, with a picture of two men boxing, proclaimed that it was August of the year 1883. A number of boxes and crates stood around the walls, and one corner was filled with picks, shovels, and crow-bars. The cabin stood in a rough clearing where pools of water were spreading in the hollows among the stumps and rocks. This building together with about thirty others – bunkhouses, stores, shacks, and even tents – made up the "town" of Sudbury. The railway track ended about three miles farther north, and during the day the construction camp was deserted except for the cooks and storekeepers.

Morgan was waiting for his foreman, Joe Marshall, and two prospectors who had recently arrived from Pembroke. A

few minutes later he saw them sloshing in single file along the muddy path leading to his office. They were accompanied by a fourth man who smoked a short clay pipe and whom Morgan recognized as Tom Flanagan, one of the blacksmiths with the construction gang. As they crossed the tracks, Morgan opened the door and welcomed them in. Marshall introduced the strangers, Thomas and William Murray. The brothers shook hands with Morgan who proffered them the only two chairs available. There were plenty of boxes for the others to sit on, but before sitting down Flanagan placed a lump of metallic-looking rock on the desk and added a handful of smaller pieces from his pockets.

"Tom and Will here would like to know if they could have a look at our latest map," said Marshall. "They plan to buy some property and want to check on its exact location."

"You're quite welcome to the map," replied Morgan, getting up and taking a large cylinder of paper from a nail keg near his desk. "Here it is," he said as he unrolled it on the desk and placed Flanagan's pieces of rock on the four corners to hold it flat. The others stood around looking down at the map while Morgan pointed out the main features of the area. "Here's Lake Ramsay, and as you can see, the line hugs the north shore till it reaches Sudbury. From here it turns abruptly northward through the worst country we've met so far. Construction wasn't too difficult coming up the Ottawa valley and along Lake Nipissing, but from here across country to the Head of the Lakes it's going to be a terrific struggle."

"I don't wonder," said Tom Murray. "Geologists call this the Canadian Shield and a shield's mighty hard to pierce. They call these rocks 'Precambrian'. They're the oldest in the world."

"I don't know about them being the oldest," said Morgan grimly, "but they sure are the toughest. We'll be a long time reaching the prairies at the rate we're going now. When we're not blasting through hills we're bridging gullies or filling in lakes and muskeg."

"We were disappointed the line didn't go south of Lake Ramsay," said Will Murray; "it's a section we thought had good mineral prospects. Of course, we can always explore it ourselves, but there's nothing like a railway blasting crew to show what's under the surface."

"As a matter of fact," replied Morgan, "the original plan was to go south of the lake, but there were last-minute instructions to take the present route. I'm not sure why. Perhaps we've missed a gold mine, but our surveyors are not interested in mineral – only in finding the best route to the west."

"There were good indications of mineral in the last cut we went through," said Marshall. "Flanagan was the first to notice it. These are some of his samples."

Morgan picked up one of the samples and turned it over in his hand. "Pretty heavy stuff," he commented. "Any idea what it contains?"

"There's copper in it," said Flanagan. "Harry Dillon took a couple o' lumps down to Ottawa an' some professor fellow down there said it was copper, but it's spoiled by another metal called nickel. This fellow said the devil himself couldn't separate the copper from the nickel."

"Well, that's too bad," said Morgan. "I guess it's gold you fellows are after?"

"Yes, gold or silver," said Tom Murray, "there's some value to them, but this copper stuff's not so good; it costs too much to smelt it out of the ore and we're not even sure it can be done."

"If that's the case," exclaimed Marshall, "why are you interested in buying the property?"

"As a matter of speculation. We can get this block of 310 acres now for a dollar an acre; some day it might be worth a thousand dollars if some big company wanted to try and develop it. This is the property right here," he continued, indicating an area just west of the track.

"I told Flanagan he should have staked a claim as soon as he found those pieces of mineral," said Marshall.

"What'd be the use o' stakin' a claim?" protested Flanagan. "If it was gold it'd be different, but you got t'know somethin' about mining t' figger out these mixed-up rocks. Minerals with a bit o' Old Nick in them is not for the likes o' me."

"Well, boys," said Morgan, "it's time we got back to work; the rain seems to be easing up – for a while anyway, but if you chaps would like to stay here," he added, turning to the prospectors, "you're welcome to use my office and copy any parts of the map you want."

"Much obliged," said Tom Murray; "that'll just suit us fine. We'll see you again before we leave. We're stoppin' at Charlie Gallagher's boardin' house for the rest of the week."

"Well, good-bye for the present, and if there's anything more I can help you with, just let me know."

"One thing you can say for these prospectors," Marshall remarked as the three men set off down the tracks, "they're

Tom Flanagan discovers the Sudbury ore.

always optimistic; imagine gambling over three hundred dollars on a piece of moose pasture like this!"

"Yes," agreed Morgan, "they sure take some big chances. I think Flanagan here has the right idea – with nickel in the ore it would be a sheer waste of money to try to do anything with it."

QUESTIONS

1. Trace the course of the Canadian Pacific Railway from Montreal to Sudbury. Why was railway-building very difficult from Sudbury to Fort William?
2. Why did Tom Flanagan not try to profit from his discovery?
3. How did the metal, nickel, get its name? Were many uses known for it in 1883? How was it regarded by miners and prospectors?
4. Look up the latest edition of the Canada Year Book or the handbook *Canada** and find out the value of the present annual production of nickel and copper in the Sudbury area.
5. With the help of an encyclopedia or a book on metals, make a list of important uses for nickel in the modern world.

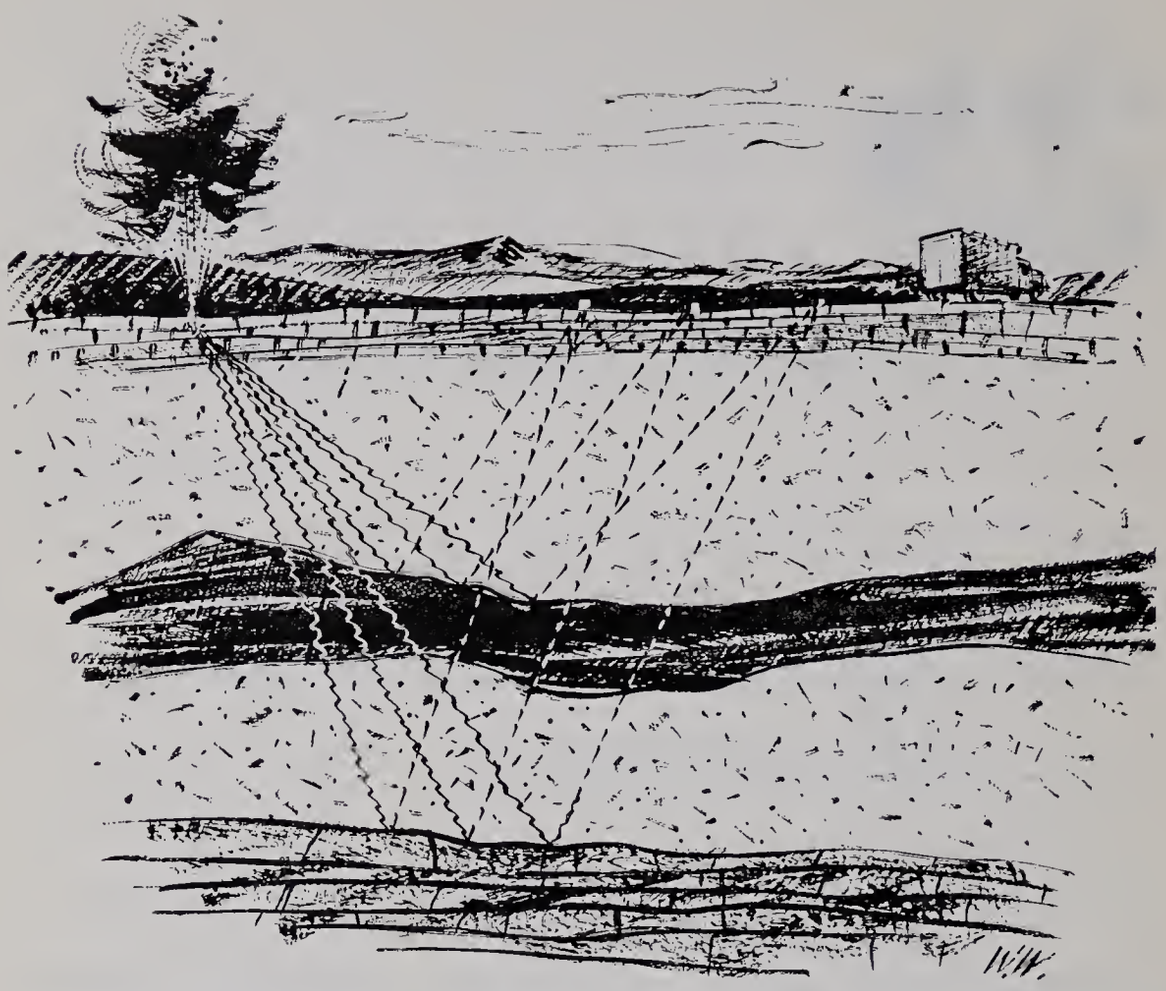
* The Official Handbook of Present Conditions and Recent Progress in Canada, published annually by the Dominion Bureau of Statistics.

PART I: THE EARTH

5 Buried Treasure

The great gold rushes to California, the Cariboo, and the Klondike show how great is the lure and fascination of a treasure hunt. In early times the search for mineral wealth was a very "hit or miss" affair, and anyone who could carry a shovel and pick considered himself a capable prospector. In those days prospecting was carried out mainly on foot or by canoe, and a hard and lonely life it must have been. The prospectors themselves rarely made great fortunes from their discoveries, as they usually staked the claims for a person or company who employed them or "grubstaked" them. Many of our richest mines are named after prospectors who first staked the claims but did not profit from the development of the mine. Benny Hollinger, on a grubstake of $35, discovered and staked the claims that were later acquired by Noah Timmins and developed into the Hollinger Mine, a mine which has since produced over $500,000,000 in gold.

In modern times the geologist and the prospector team up



The seismic survey shows ground structure and possible oil-bearing layers.

to bring all the resources of science and technology to bear on the age-old quest for buried treasure. The geologist studies and maps the various rock formations and learns the conditions necessary for the occurrence of each type of mineral. The prospector, using all the information the geologist can provide, seeks out the most likely places, searches for definite clues, and brings out samples for analysis. It is not enough for the prospector to find indications of mineral. There are many cases in which valuable minerals such as gold and platinum are present in the rock but the cost of extracting them would be greater than their market value. What the prospector hopes to find is *ore* that consists of "mineral-bearing rock that can be mined at a profit". If the surface indications are encouraging, underground exploration will be made by diamond drill-

ing, and this will finally determine whether or not profitable mining operations can be carried out.

The modern prospector does most of his travelling by plane or helicopter, and has a great variety of scientific instruments at his disposal that were completely unknown in the last century. A very valuable instrument in modern prospecting is the airborne magnetometer, a device that is suspended below an aircraft and records magnetic variations in the ground over which it passes. Other scientific instruments that help to detect the presence of mineral are the Geiger counter, the ultra-violet lamp, and the gravity meter. Oil companies have a very interesting way of obtaining information about rock formations below the surface. A small explosion is set off at the surface, and listening devices in the surrounding area pick up the echoes from the layers of rock below. This is called the seismic method, from the Greek word *seismos,* an earthquake. By comparing the echoes from different depths and the speed with which they return, valuable information can be obtained about the underlying strata and the probability of finding oil.

There are four main methods of extracting the mineral from the earth.

1. PLACER MINING

In placer mining, water under great pressure is used to wash down the sand and gravel from which the gold is extracted. In some cases huge dredges are used to dig up the deposits and extract the gold. The separation depends on the great weight of gold, which causes it to stick to the bottom of the sluices while the lighter material is washed away. Panning is the same method on a small scale; it was the method used by the prospector in the gold-rush days.

2. OPEN PIT

Open-pit mining consists simply of digging a huge pit in the surface deposit and removing the ore by power shovels and trucks. Frequently iron and asbestos (and sometimes the ores of nickel, copper, and other metals) are mined in this way.

3. SINKING A SHAFT

If the mineral lies far below the surface a shaft is usually constructed down to the required level and then cross-cuts are made through the ore body. The headframe contains a hoist engine to operate the "cages" that carry the miners and the "skips" that bring up the ore. A modern mine sometimes contains hundreds of miles of subterranean passages complete with electric trains carrying ore to the loading stations, from where it is hoisted to the surface.

4. DRILLING

When the substance to be recovered is a liquid or a gas, or if it can be melted or dissolved, it is brought to the surface through pipes or drill holes. This costs much less than shaft mining. Petroleum and natural gas are obtained in this way. When beds of sulphur occur far below the surface, superheated water is pumped down an outer pipe, forcing the melted sulphur up an inner pipe. In the case of salt, water is pumped down one pipe and the salt solution comes up another. The brine is then evaporated to obtain the salt.

QUESTIONS

1. Name four scientific instruments used by the modern prospector.
2. What is ore?
3. Describe the seismic method of prospecting for oil.
4. Describe four methods of mining. What conditions determine the method of mining that will be used?
5. Make a scrapbook and wall charts illustrating prospecting and mining activities in Canada.
6. On a large outline map of Canada mark the following mining communities and indicate the substance mined at each place.

   Newfoundland: Deer Lake (zinc, lead, copper); Grand Bank (fluorspar); Carbonear (iron).
   Nova Scotia: Sydney (coal); Inverness (coal); Kentville (gypsum); Truro (salt).
   New Brunswick: Moncton (gypsum); Stoney Creek (coal).
   Quebec: Rouyn (gold); Noranda (copper, silver, gold); Val d'Or (gold); Knob Lake (iron); Thetford Mines (asbestos); Sherbrooke (lead, silver, zinc); Allard Lake (titanium).
   Ontario: Sudbury (nickel, copper, platinum); Timmins (gold); Kirkland Lake (gold); Steep Rock (iron); Cobalt (cobalt, silver); Matheson (asbestos); Marmora (iron); Caledonia (gypsum); Bancroft (mica); Elliot Lake (uranium).
   Manitoba: Gypsumville (gypsum); Flin Flon (zinc, copper); Thompson (nickel); Lynn Lake (nickel).
   Saskatchewan: Estevan (coal); Brock (gas); Coleville (oil); Uranium City (uranium); Moose Jaw (sodium sulphate); Beaverlodge (uranium).
   Alberta: Leduc (oil, gas); Turner Valley (oil, gas); McMurray (bituminous sands); Drumheller (coal).
   British Columbia: Kimberley (lead, silver, zinc); Kitimat (smelter); Salmo (tungsten); Trail (smelter).
   North West Territories: Port Radium (radium, uranium); Yellowknife (gold); Norman Wells (oil).
   Yukon Territory: Klondike (gold); Dawson City (gold).

7. Copy this chart into your notebook and fill in the information from the latest edition of the handbook *Canada*.

MINERAL PRODUCTION FOR THE YEAR 19.....

Province or Territory	*Value*	*% of Total*
Newfoundland		
Nova Scotia		
New Brunswick		
Quebec		
Ontario		
Manitoba		
Saskatchewan		
Alberta		
British Columbia		
N.W. Territories		
Yukon		
Total Value		

8. Make a three-column table similar to the above, using the headings MINERAL, QUANTITY, VALUE. Under the first heading enter the following minerals and fill in the remaining two columns from the latest edition of the handbook *Canada*: Asbestos, Coal, Cobalt, Copper, Gold, Gypsum, Iron ore, Lead, Magnesium, Mica, Natural gas, Nickel, Petroleum, Platinum, Salt, Silver, Tungsten, Uranium, Zinc.

6 The Prospector

Benny's arms and shoulders ached. The sudden squall had almost overturned his canoe and he had to struggle with all his might to keep it headed into the waves while he cautiously worked his way toward the lee of a rocky point.

Once in the quiet water he quickly forgot his recent danger and began to scan the steep face of the rock for mineral stains. At one place a large vein ran diagonally across the dark towering rock, but it was far above the water and there was no landing-place near by.

It was late afternoon, so Benny decided to look for a camping site and walk back to the bluff in the morning. He had to follow the rocky shore for more than a mile before he found a suitable place to beach his canoe and make camp.

Soon his campfire was burning on a rocky ledge, with his tea pail wedged into one corner and a lump of bannock baking before the open fire. His supply of salt pork was getting low, so he ate the bannock with some bacon grease and finished up

with some dried apples for dessert. Then, with a stick, he lifted the pail of furiously boiling tea and set it aside on a flat stone. While the tea was cooling he constructed a rabbit snare, for a prospector in the year 1909 had to live off the land to a considerable extent if he were to survive for long periods in the bush.

When he had finished his tea he washed his tin plate and cup in the lake and with a small axe in his hand went off to set the snare. A short distance from camp he heard the sound of falling water and, working his way in the direction of the stream, he came out on a high rock overlooking the falls. In the pool below stood a great black bear up to his middle in water. The bear was fishing, and with lightning strokes of his paw he flipped squirming suckers onto the bank where he would later have a feast. Benny watched in fascination for a few minutes and then went silently on his way without attracting the bear's attention. Soon he found a rabbit trail and set his snare, triggered to a sapling bent double so that the rabbit would be snapped up out of reach of the hungry weasel. As he walked back to camp, a startled deer with white flag aloft darted away with graceful bounds over the logs and boulders.

The following morning Benny woke to find that a porcupine had chewed his tumpline and packstraps, attracted by the salty sweat which they contained. However, this misfortune was soon forgotten when he found a rabbit in his snare and knew that he would dine well for one day at least. When his camping chores were done, he set off for the rocky point where he had seen the quartz vein.

Arriving there, he climbed up the high bluff and examined the vein carefully, but there was no sign of anything valuable in it. In fact there was no indication of mineral anywhere in the vicinity.

He had just about decided he would have to return to Haileybury and report to the friend who had "grubstaked" him that his thirty-five dollars had been spent in vain, when his attention was drawn to a high outcrop of rock forming a

ridge about five miles to the north-east. His supplies were almost exhausted and it would take many days of hard travelling to get back to the railway, but he knew that he could not go back till he had looked at that ridge.

Very early the next morning he cached his canoe and equipment as safely as possible, and taking only a packsack, a small axe, and his prospector's pick he set a compass course and headed off in the direction of the outcrop.

Benny Hollinger was a good woodsman. Before taking up prospecting he had been a lumberjack and was as much at home in the woods as a city dweller in his familiar streets. His way led through an alder swamp, where he walked ankle deep in water with a cloud of mosquitoes hovering about him. Beyond the swamp a stand of mature trees with little underbrush made easy going and he strode along at a steady pace. A partridge, pretending a broken wing, tried to lure him away from her clutch of young ones, but she need not have been concerned, for Benny had more important things in mind. Soon he came to a creek meandering out of a small lake and paused to drink and splash the cool water on his face. A muskrat, chewing a piece of reed, eyed him thoughtfully but without fear.

Beyond the creek the land rose rapidly towards the bare ridge of rock and in some places the ascent was almost perpendicular. As he scrambled up the irregular terrace his foot slipped and tore a layer of moss off the damp rock. Benny's eyes almost popped out of his head, for there beneath the moss was a milky-white vein of quartz thickly spattered with flecks and even nuggets of *gold*.

QUESTIONS

1. Compare the life of the old-time prospector with that of the modern prospector.
2. Why were prospectors called "sourdoughs"?
3. What is meant by a "grubstake"?
4. Describe some of the interesting forms of wild-life that a prospector would be likely to see.
5. Name at least six famous Canadian prospectors and tell some interesting facts about their discoveries.

7 Making the Best Use of Our Mineral Resources

Since our mineral resources can never be replaced it is of the utmost importance not to waste them or use them foolishly. Conservation as applied to mining means using the most efficient and economical methods to extract the greatest amount of mineral that the mine can yield, and then using the product in the most intelligent and beneficial way. Many of the gold-fields were abandoned as soon as the obvious and fairly accessible gold was mined, and large quantities of the yellow metal may still be recovered by dredging the old workings and using modern methods to extract the gold. The same is true of the silver mines, where very valuable quantities of silver have been recovered from the rock dumps of what were once considered to be worked-out mines.

Research has led to the discovery of new and more efficient methods, such as "flotation", for the separation of minerals from their ores. This is mining conservation at its best, for it has made it possible to extract great quantities of valuable

mineral from low-grade ore that would previously have been abandoned. Mining methods and working conditions in the mines are constantly being improved, and strict precautions are taken to prevent accidents. All of this adds up to greater efficiency and greater production.

Discovering new and valuable uses for minerals once considered useless or actually harmful is an extremely effective form of conservation. Nickel, once despised because it spoiled the copper ores, has become one of the most essential of our modern metals. Cobalt, which was thrown on the dumps when silver was being mined, is now eagerly sought for a variety of important uses. It is alloyed with iron and other metals to make jet-engine parts that must withstand very high temperatures; it is also used in metal-cutting tools and in making permanent magnets.

Large quantities of iron were formerly lost in the slag that is a waste product of the copper-nickel smelters, but modern research has discovered a method of utilizing the iron and alloying it with nickel. The new iron plant at Copper Cliff, Ontario, built at a cost of $19,000,000, is an illustration of the importance that the International Nickel Company attaches to metal conservation. Another example from the same area is the plant operated by Canadian Industries Limited to manufacture sulphuric acid from the waste sulphur-dioxide gas that comes from the smelters. The Consolidated Mining and Smelting Company at Trail, B.C., also utilizes the waste gas from the lead-zinc smelters, producing sulphuric acid and combining it with phosphate rock to make fertilizers. Tailings from the Kimberley mines have been used to produce sulphuric acid, and the by-products of this operation have been stockpiled in the expectation of extracting iron at a later date. In Alberta sulphur is being obtained as a by-product of natural gas. Some of it is sold to western pulp-mills for the making of paper, and large quantities are also available for export.

Mining companies are rapidly becoming more conservation-conscious, and the old wasteful ways will no longer be toler-

ated. Nevertheless there is still much to be done by means of research and careful management to further reduce wasteful practices and to solve the problems of waste disposal. The pollution of air and water by the waste products of cities, mines, and industries is one of the great problems of conservation, and we will deal with it in more detail in a later chapter.

In the early days of the oil industry little conservation was practised. Oil derricks were placed so close together they looked like trees in a forest, and much of the oil that could have been obtained by better spacing was never extracted from the ground. Gushers ran unchecked for days and sometimes caught fire. No attempt was made to conserve the gas that came with the oil, and it either escaped into the atmosphere or was burned in a flare. This was doubly wasteful because it is the gas pressure that causes the oil to flow, and the loss of gas made necessary the use of pumps to bring the oil to the surface. If the pumps operated faster than the oil could seep through the rock, water rose in the well and it was ruined.

Oil companies today go to great lengths to avoid waste, and endeavour to extract the maximum possible yield of both oil and gas from every well. As oil is removed from the field and the pressure decreases, engineers build up the pressure again by pumping gas back into the system. This is called *gas-cycling,* and it greatly extends the life of an oilfield and increases the amount of oil recovered from it. The gas is later recovered and used. In certain formations water may be pumped in below the oil to create the necessary pressure. The days of the gusher are gone. Oil wells today are quickly capped and the rate of flow is carefully adjusted. If the oil were allowed to flow too fast, the pressure would soon be lost and the total yield would be low. To prevent this, oil is withdrawn so slowly that the oil level of the field is lowered evenly. Time is allowed for oil from the more distant parts of the field to seep into the areas where the well is located. Another reason for limiting the rate of flow is that the best storage place for oil is underground. If it is stored above ground

expensive tanks have to be built, there is grave danger of fire, and there are considerable losses due to evaporation of the oil and gasoline. It is good conservation practice, therefore, to regulate the flow of oil to meet the demand, and to keep stores above ground to a minimum.

Oil, as it reaches the surface, is frothy with gas. It is first led into a tall cylinder, where the clear oil settles to the bottom and the gas goes to the top. The gas is then led off to a *gas conservation plant,* where sulphur is extracted and three different types of gas are separated. These are (1) *dry gas* (methane and ethane) which is distributed through pipelines as natural gas, (2) *propane* which is easily liquefied and is distributed in steel cylinders, and (3) *natural gasoline,* a very light gasoline which is added to ordinary gasolines. Pumping is still used when a well has lost its pressure and it is too expensive to renew the pressure by gas-cycling. Some of the earliest wells, such as those found in Ontario and Pennsylvania, are still capable of pumping a barrel or so of oil a day.

Conservation of our mineral and fuel resources is not restricted to the operation of big companies. We are conserving fuel when we insulate our homes and when we keep our furnaces and car engines at maximum efficiency. We conserve metal when we undercoat our cars and when we substitute glass or plastic for metal containers. Conservation of metal usually means protecting it from corrosion. We all know how rapidly a car body deteriorates when the paint is scratched or scraped off. The flint arrowheads of Stone Age man are frequently found, but the earliest steel weapons have long since crumbled into dust. In fact, if we ceased our efforts against rust for one generation there would be little left to show that man had ever learned how to extract iron from its ore. It is estimated that every year over 30,000,000 tons of iron and steel are changed into useless rust. For every pound of steel we conserve by preventing it from rusting we also conserve the four pounds of coal that have to be used in making the steel. We also save many other costs such as labour and transportation.

To protect iron from rusting we must protect it from the action of oxygen and moisture. This may be done in a variety of ways. For example, we separate the oxygen from the metal by means of paint, as in the case of car bodies, or by means of enamel, such as we see on stoves and wash basins. We may cover the iron with zinc (galvanized iron), or with tin as in the familiar "tin" cans, or we may coat it with nickel (car bumpers), or with chromium (bathroom taps). In order to get a coating of zinc or tin, the iron is dipped into the liquid metal. Nickel and chromium are deposited on the iron by means of electricity (electroplating). Before pipelines for oil or gas are laid in the ground they are thoroughly coated with enamel, reinforced with glass fibre, and wrapped in asbestos felt. Big guns, tanks and even warships have been "moth-balled" by sealing them in plastic-like coverings to protect

Big-inch pipe is wrapped with Polyken Pipeline Coatings by high-speed automatic machinery. One mechanical arm unwinds the tape in a continuous spiral, while another applies the felt overwrap.

Kendall Company, Polyken Sales Division

them for long periods against corrosion. Another method of preventing corrosion is by blending metals together to make a rust-proof *alloy*. Chromium alloyed with steel gives "stainless steel", and copper alloyed with nickel gives "monel metal".

It is important to remember that the mere preservation of a substance is not in itself the most important thing. It is the use we make of it that matters most. Particularly in the case of a non-renewable resource, we should endeavour to make sure that the purpose for which it is being used is the best purpose. Perhaps this is what an ancient writer had in mind when he spoke of a time when swords would be beaten into ploughshares and spears into pruning-hooks.

QUESTIONS

1. Name three valuable by-products of the mining industry which were previously rejected as waste.
2. Compare the early methods in the oilfield with the modern practice of conserving oil and gas.
3. Why is it better to hold oil and gas underground till they are needed?
4. Explain the following terms: gusher, gas-cycling, cracking, flotation, electroplating, alloy, galvanized iron.
5. What is meant by the statement "More oil has been found in the laboratory than by the drill"?
6. Name ten ways of preventing rust and corrosion.
7. Describe the best methods of insulating a home or building.
8. The National Research Council found that good insulation, including storm doors and windows, could reduce heat losses in homes by 62%. If a home-owner used 1500 gallons of oil to heat his uninsulated home for a year, how many gallons would he save by insulating it? In what other way would he benefit from the insulation?
9. Discuss uranium from the point of view of "using our resources in the most intelligent and beneficial way".

PART II: THE SOIL

"Half of our misery and weakness derives from the fact that we have broken with the soil and that we have allowed the roots that bound us to the earth to rot. We have become detached from the earth, and we have abandoned her. And a man who abandons nature has begun to abandon himself."

PIERRE VAN PAASSEN

8 The Sustainer of Life

In Chapter 1, we saw that the crust that first formed on the cooling earth was a hard igneous rock. Over immense periods of time this rock underwent both chemical and physical changes, and deposits of clay were gradually formed. Some of the rock was chipped and powdered by the action of the weather, and washed into the seas, where it settled and hardened into sedimentary layers. Great masses of sedimentary rock were later elevated into land and even into mountain ranges.

Probably the first plants to appear on the rocky surface of the earth were the lichens, followed after immense periods of time by mosses, ferns, grasses, shrubs, and finally trees. When plants appeared upon the earth their roots spread into the damp crevices of the rocks to extract dissolved minerals, and

their leaves spread upward into the air to extract carbon dioxide. Fallen leaves and dead plants added something new to the surface of the earth, a substance called humus. The humus, mixing with tiny rock fragments such as sand or clay, formed a thin, fertile carpet over most of the land. As ages passed, the carpet of topsoil gradually became thicker but it was a very slow process. The average depth of topsoil on the earth today is estimated to be between seven and ten inches.

It is important to realize that when a plant dies and decays it is not merely returning to the soil substances taken from the soil. Only about 5% of the weight of a plant comes originally from the soil; the remaining 95% is built up from water and carbon dioxide by a process we call photosynthesis. Thus the decay of plants is constantly adding to the soil essential life-giving substances derived from air and water and synthesized by the action of sunlight. During the seventeenth century a Flemish doctor grew a tree in a tub of earth, and for five years he added nothing but rainwater. At the end of that time the tree had gained 164 lb. in weight while the soil in the tub had lost only a few ounces. By this experiment he showed that nearly all the material of the tree had been built out of carbon dioxide and water.

We should not think of the soil simply as "dirt". Healthy soil is an extremely complex mixture consisting of mineral particles in the form of sand, silt, or clay, and organic matter in the form of humus. The spaces between the particles contain air and water, and teem with tiny forms of life, both plant and animal. In certain soils there are as many as 50,000 earthworms to the acre and also innumerable grubs, centipedes, and other creeping things. Besides these, every spoonful of soil contains millions of bacteria, moulds, and fungi far too small to be seen without the aid of a microscope.

These living things do not simply inhabit the soil, *they are part of it,* and through their activity the soil is constantly being changed and redistributed. Earthworms keep the soil porous and bring up earth from greater depths to the surface.

This dark, deep layer of topsoil is the product of centuries of weathering, the accumulation of plant and animal remains, and the work of many living organisms. The less fertile subsoil, which is lighter in colour, has little or no organic matter.

U.S. Department of Agriculture

Some bacteria make nitrogen from the atmosphere available to the roots of plants as nitrates, and others bring about the decay of dead plants and animals.

We are inclined to think of decay as something unpleasant and undesirable, but if dead plants and animals did not decay, the elements they contain would be locked up for ever and could never be used to sustain new life. The bacteria that bring about decay change the dead organic matter into a form that can be absorbed by plants, so that in a sense it becomes alive again. There are many things that operate in *cycles* like this, for Nature uses the same materials over and over again in the orderly revolution of the wheel of life. For example, one of the most important elements that enters into the composition of plants and animals is nitrogen. Although nearly 80% of the atmosphere is nitrogen, plants cannot take it in, and must rely upon nitrogen present in soluble compounds in the soil. Under natural conditions the nitrogen compounds in dead plants and animals are returned to the soil by the process of decay; here they enter into the structure of new green plants, which in turn may be eaten by animals. The dead plants and animals again return to the soil, along with all animal waste, and so the *nitrogen cycle* continues.

Above the parent rock there are two kinds of soil, subsoil and topsoil. The topsoil varies from a few inches to several feet, but averages less than ten inches. Since all life depends upon plant life and plant life depends mainly upon topsoil, this thin layer is very precious, for it must nourish the great and expanding populations of the earth. Topsoils are classified under four main headings: sandy soils, loams, clay soils, and muck soils.

1. SANDY SOILS

The sandy soils are from 80% to 100% sand, the remainder being clay, silt, and humus. Sandy soils are low in plant nutrients and living organisms, and have a poor water-holding capacity. They are always in danger of being blown away by

strong winds unless held in place by trees or by a cover crop.

2. LOAM SOILS

Loams are the most desirable farm and garden soils. They may contain from 30% to 50% sand and up to 15% clay, the balance being made up of organic matter, or humus. Loams are rich in the elements that plants require, and if properly worked they have good aeration and good water-holding capacity. Loams that have an excess of sand are called *sandy loams*. If a considerable part of the sand is replaced by silt they are called *silt loams,* and if they are replaced by clay they are called *clay loams*. Sandy loams do not have good water-holding capacity, and the valuable minerals are likely to be leached away and may have to be replaced by frequent applications of fertilizer. Silt loams have a high water-holding capacity, but they tend to harden when they become dry and are more difficult to manage. Clay loams may contain as much as 30% clay. They have good water-holding capacity and high mineral content, but they require careful working to provide good aeration and drainage. When well managed they are rich, productive soils.

3. CLAY SOILS

Clay soils contain more than 30% clay, but they may be very productive if good quantities of organic matter are present. They are rich in minerals and have a high water-holding capacity, but they become gummy when wet and are apt to bake and crack when dry. Nevertheless they are very productive when carefully managed.

4. MUCK SOILS

Muck soils consist mainly of well decomposed peat. They contain as much as 90% organic matter, but they lack many of the minerals supplied by the rocky particles of other soils. Although they are rich in nitrogen they require large quantities of fertilizer to supply the other necessary elements. Muck soils

are often formed by the draining of marshes. They are dark, porous soils and heat up quickly in the spring. They are suitable for market gardens and the production of vegetable crops such as onions, celery, and lettuce.

The essential elements which plants obtain from the soil include nitrogen, potassium, phosphorus, iron, calcium and sulphur. Other elements such as chlorine, iodine, zinc, manganese, and copper must be present to produce healthy plants, but since only minute amounts of these are necessary they are called *trace elements*. Hydrogen and oxygen are obtained from water, and carbon from the carbon dioxide of the atmosphere. These are the same elements that are necessary for human nutrition, and we obtain them either directly from plants or through meat and dairy products. A nation's soil is therefore the basis of its people's health as well as its prosperity, and it is fortunate for us that our soils developed under conditions that enabled them to retain nearly all the essential minerals. Our most fertile soils are those that formed under grassland prairie conditions where there is fairly low rainfall. The soils that formed under forest cover in Eastern Canada and the coastal regions of British Columbia are less fertile, partly because of the high rainfall which tends to leach away soluble minerals from the soil.

Although Canada is the second largest nation in the world (surpassed in size only by the U.S.S.R.) its soil resources are not as extensive as might be supposed. The Great Central Plain, which includes the three Prairie Provinces, is often referred to as one of the world's great bread-baskets, but years of intense cultivation have depleted its fertility and drastic changes in methods of land management may be necessary to prevent parts of it from becoming desert. The Eastern provinces are for the most part rocky, and the Canadian Shield covers the greater part of Ontario and Quebec, leaving only the southern regions capable of intensive cultivation. In the west, mountain ranges cover most of British Columbia, and

only comparatively narrow valleys are available for farming, fruit-growing, and ranching. In spite of its great size Canada actually has less land under intensive cultivation than France!

Millions of bushels of wheat, oats, and barley are exported from Canada each year, most of it from the prairies, where more than 36,000,000 acres are devoted to the growing of grains. This means that enormous quantities of nitrogen and other essential elements are taken from the soil, only a very small portion of which is replaced by fertilizer. Agriculturists call this an *extractive* system of farming, and it must lead to the eventual depletion of the soil, just as an oil well must eventually run dry.

Many agricultural scientists think that we should have in Canada a national plan for maintaining soil fertility and rebuilding soils that have lost much of their fertility. Such a plan has been undertaken in the United States, where it is estimated that at least 100,000,000 acres of farm land have already become useless owing to human mismanagement. However, it is not wise to expect the government or some other agency to take *all* the responsibility for repairing the damage that has been done by neglect or mismanagement of the soil. Every farmer, and, to some extent, every informed individual, can do his share in the work of restoring fertility and preventing further loss of the indispensable soil.

A good farmer is one who enjoys farming and who sees his farm as more than a means of making money. He is a man who takes pride in the state of his land, his crops, and his livestock, and who sees himself as a co-worker with Nature, helping and quickening the processes that Nature herself employs. A good farmer is acquainted with many skills. He must be to some extent a botanist, a mechanic, a veterinarian, and a business man. He is industrious, but what is more important, his industry is well directed and he knows how to make efficient use of labour-saving devices. He is a man who knows how little he knows, and is always anxious to learn by reading, by observation, and by experiment.

This is the kind of farmer we must have, and is in fact the only kind that Nature will tolerate. However, humanity is the loser when valuable land is ruined by the ignorant and lazy before they are forced off the land by their own incompetence.

QUESTIONS

1. Why is topsoil called "the sustainer of life"?
2. Describe how natural forces gradually cause rock to crumble.
3. What is humus and how is it formed?
4. What are the main constituents of good topsoil? What is its average depth?
5. Why is decay an important process in nature? Describe what would happen if organic substances did not decay.
6. What is meant by "the nitrogen cycle"? Give examples of other cycles in nature.
7. What happens to the nitrogen cycle in the wheat-growing areas of the prairies?
8. Name four types of topsoil.
9. Describe the characteristics of each type mentioned in your answer to question 8.
10. Name six important elements that plants require.
11. What are trace elements? Name three trace elements.
12. What is meant by the term "extractive farming"? Discuss this from the point of view of conservation.

PART II: THE SOIL

9 Tom Pratt

Tom Pratt did very little reading. He always claimed his farm kept him too busy, but tonight he was very interested in the page of "Want Ads" in the local paper. The two columns that held his interest were "Help Wanted" and "Farms for Sale". He had decided to give up farming and find a job that would bring in a steady pay cheque.

At one time it had been Tom's greatest ambition to own this farm. He had been brought up on a farm in the same township, where, for one reason or another, the family had always been in financial difficulties. This, according to Tom's father, was the fault of the land, although he sometimes blamed the weather, the government, and even his neighbours. When Tom wanted to leave school his family made no objection. His father had little respect for what he called "book learnin' ", and in any case he wanted his son to help on the farm and save the cost of a hired man.

Whenever they drove past the Spencer farm on their way to town, Tom's father used to say, "No wonder he has good

crops. Anyone can make money if he has good land, but if I was John Spencer . . ." and he would go on to list all the mistakes Mr. Spencer was making and explain to Tom how it should have been done.

Years later when old John Spencer died and his farm came up for sale, Tom got enough money together for a "down payment" by selling the farm he inherited from his father. It was

a great day in their lives when Tom, his wife, and their two small children moved into the old Spencer home. Although there was still a large mortgage on the property, Tom felt that from now on, life would be pleasant and easy – the kind of life to which he believed himself entitled. He had only to carry

Severe washing in a winter-wheat field is illustrated here. A 48-acre drainage on a 5-per-cent slope cut this gully 8 feet deep and 15 feet wide.

U.S. Department of Agriculture

out a simple routine and the farm would prosper for him as it had for Mr. Spencer.

There was no doubt that it was a good farm, although considerably more hilly than the farm Tom had been used to. Mr. Spencer had made it pay in a variety of ways. He kept an excellent Jersey herd and sold milk and cream to the city dairy; he kept some pigs and some beef cattle and grew all the food that they required. His biggest cash crop was wheat, but he also grew hay, oats, corn, and potatoes. He had a well-kept garden which supplied the household needs, and a small orchard with Yellow-Transparent, Spy, and Duchess apples. Besides this there was a woodlot of about fifteen acres with a small stream running through it. From the woodlot Mr. Spencer obtained fence posts, firewood, and maple sugar, and sold an occasional mature tree to the sawmill.

Tom decided not to keep any livestock. He was not going to be tied down by the chores of feeding and milking. He would simply grow wheat and not waste time with a lot of trivial sidelines. The orchard could look after itself, and as for a garden, he might plant a few rows of vegetables but he would probably have more important things to do.

The first year his crops were good and when they were harvested he celebrated by buying a new car. It was obvious that making money on this farm was an easy matter; in fact, to Tom's way of thinking it required only three operations – ploughing, seeding and harvesting. He made quite an impression with his new car that year and gave a good deal of advice to the surrounding farmers.

The next year was a very wet one and Tom got off to a bad start. His land was not properly prepared, seeding was late, and the crops were poor. After every heavy rain, rivulets of water poured down the hillsides between the thin wheat stems, carrying tons of good topsoil into the ditches. This was a bad year for Tom financially, but he did not intend to spend any less on that account. He therefore made a deal with the planing-mill at Elmville to take some of the best timber from

his woodlot. At first he had intended to sell only enough wood to make up for the poor yield of wheat, but when he realized the demand for wood and the price he could obtain, he allowed the mill to buy up most of his good lumber, and once again he felt rich and successful. For a while he thought of spending some money on fertilizer, but, on thinking it over, he convinced himself that the poor yield was due to weather conditions. Next year things would be back to normal anyway so why waste money on fertilizer; instead he would use it for a hunting trip in the fall.

Thus Tom kept on farming, ploughing up and down the hills year after year, year after year planting the same crops in the same fields, and each year harvesting a crop poorer than the one before it.

When he finally became convinced that he should use some fertilizer, he had no money to buy it, and he could not obtain another loan as he was behind in his payments at the bank. He also owed money on his car, and the house was badly in need of repairs. In order to eke out a living he sold the rest of the good timber to the planing-mill and allowed cutters to come and saw up the smaller trees for firewood.

The hilly part of the farm was now so poor that it was not worth cultivating. Tom seeded it in grass and rented it to a neighbour who put his sheep to graze on it. The sheep kept the grass cropped very closely and their constant movement packed the earth so hard that water could not sink in, but ran down the slope in sheets and rivulets. Bare spots appeared on the slopes and the sharp hoofs of the sheep started numerous shoe-string gullies that spread like veins over the hillsides. With each heavy rain these grew deeper and wider and it soon became apparent that the land was ruined even for grazing.

For a while Tom kept up the pretence of farming. One winter he got a temporary job in a nearby city, but he knew that things could not go on this way.

Reading the "Help Wanted" columns he came across an advertisement for a driver of a transport truck. The wages

seemed good to Tom when he thought of his present financial condition, and he decided to apply. Of course, if he got the job he would have to sell the farm – that is, if he could find anyone to buy it.

QUESTIONS

1. What was the probable fate of the orchard on Tom's farm? Explain.
2. Make a list of the useful purposes served by a well-kept woodlot.
3. Why should cattle be prevented from grazing in a woodlot?
4. Compare the probable condition of the stream before and after the woodlot disappeared. Explain.
5. What is meant by "crop rotation" and what purpose does it serve?
6. What is likely to be the result of overgrazing, especially on hilly land?
7. What are "shoe-string gullies"? What are they likely to become?
8. Make a list of the mistakes made by Tom Pratt in the operation of his farm.
9. What should a farmer know about his soil before applying fertilizer?
10. In what ways could Tom Pratt have obtained valuable information about good farming methods? Why did he not do this?

PART II: THE SOIL

10 Erosion

The great enemy of topsoil is erosion,* the constant wearing away of the land by the action of wind and water. Evidence of water erosion can be seen in the tiny rills at the edge of the highway after a rain, and in the Niagara Gorge and the Colorado Canyon. Wind erosion is seen in the blowing away of loose topsoil and sand by dust storms and sand storms.

When the land was covered by forest and grass, erosion of topsoil was practically unknown; in fact, topsoil under these conditions was increasing rather than wearing away. As soon as the forest was cleared and the grass lands ploughed, erosion began.

In pioneer times land unsuited for farming was often cleared and cultivated. The result was that it soon became badly eroded and was abandoned in favour of another newly cleared area. The new land soon suffered the same fate, and the settlers then moved to another fresh place, like the people in

* Latin—*rodere*, to gnaw.

Alice in Wonderland's mad tea-party. More than a hundred years ago a traveller described a certain section of the countryside as "a scene of desolation that baffles description, farm after farm worn out, washed and gullied so that scarce an acre could be found fit for cultivation".

The study of erosion is not just a school subject, or something to be learned for examinations. The proper understanding and control of erosion will determine the difference between food and famine in the next few generations. If, instead of topsoil, you could see the food it might have produced being washed away, or if you could see the bodies of the people who died yesterday of starvation in the world's densely populated countries, you would understand better what the loss of topsoil really means. Our world population is increasing at a very rapid rate. About three hundred years ago it was only 500 million or a half a billion; now it is about 3 billion and it is estimated that it will be 6 billion by the end of the present century. Erosion, therefore, is not merely loss of soil, it is creeping death in the form of poverty, starvation, and disease.

Erosion is the result of deforestation, overgrazing, and bad farming methods. Already about one-third of the original topsoil of our farms has been lost and we are continuing to lose it at a very rapid rate. Recent studies show that an acre of land with a slope of only 5% may lose as much as 42 tons of topsoil in a single season.

Erosion is very easily seen when it takes the form of gullies, but there is another form of erosion where the whole surface of the slope is washed away evenly. This is called sheet erosion and may be even more damaging than gully erosion, especially because it often goes unnoticed. As a result of water erosion enormous quantities of topsoil are carried away to the lakes and oceans and lost for ever.

If you fill a milk bottle with water flowing from a cultivated field during a rain-storm and let it settle, you may find a quarter or more of the bottle is filled with soil. Workmen

building bridge piers at Charlottetown, P.E.I., had to go through ninety feet of mud to reach solid foundations. This mud, brought down by the Hillsborough River, was once the fertile topsoil of Canada's "Garden Province". In New Brunswick it has been calculated that the St. John River, in one week of high water, carries down to the sea enough topsoil to cover 3000 acres to a depth of one inch, and measurements made on the Humber River at Toronto indicated that, when in flood, it was carrying topsoil into Lake Ontario at the rate of 2400 tons per hour. These are not exceptional cases; rather they are typical of what is taking place in many of our rural communities.

Such a rapid loss of topsoil is bound to show up in poorer crops, abandoned farms, and growing deserts. In a survey of an eroded area in Ontario 75 farms were classified as poor or fair and 44 farmhouses were completely abandoned, each one a mute testimony to the hope, toil, and despair of its former owners. Some of this land was unproductive from the start and should never have been cleared of its forest cover. In some cases the land was good to begin with but was farmed without wisdom or foresight. Productivity decreased, money became scarce, and the children left school at an early age to find work in the city. Finally the once-prosperous farm became a liability and was abandoned to the rain, the wind, and the weeds. This is not just a personal tragedy, it is a tragedy that affects the whole community. The abandoned farm is a menace to its neighbours because of the erosion that goes on unchecked and spreads over the adjoining fields. Business is affected, for what we call business and industry consists largely of producing, transporting, processing, and selling the products of the soil. Abandoned farms buy no farm machinery and pay no taxes. Abandoned farms mean jobless people who are forced to live in slums, adding to the congestion of cities and the problems of relief.

The damage done to the farm is not the only damage done by erosion. River mouths and harbours are filled with sediment

and cease to be navigable, reservoirs and irrigation ditches become silted and require costly dredging, gravelly streams are choked with sediment that destroys the spawning-grounds of fish and smothers the small organisms on which the fish feed.

Although water left unchecked does great damage to the soil, lack of water may have equally devastating results. During periods of drought cultivated soil becomes dry and powdery and is blown into the air by every gust of wind. In 1941 there were about 4 million acres of abandoned farmland in the Prairie Provinces. This great area, ruined by drought and wind erosion, was capable of producing an annual crop of 60 million bushels of wheat. Soil blown from the prairies blackened the air and made the sun look red, while immense curtains of dust drifted over the eastern cities and vanished in the Atlantic Ocean. The sparse crops that remained were set upon by swarms of grasshoppers, and the drifting tumbleweed took possession of the fields. "It's worse than the papers say," declared the owner of a large tract of windswept land; "our fences are buried, the house hidden to the eaves, and our pasture, which was kept from blowing by the grass, has been buried and is worthless now."

While wind erosion and dust storms are usually associated with dry, treeless regions, they are not restricted to these locations. Ploughed or cultivated fields of any kind are apt to dry out quickly and be blown about by high winds. One of the worst features of such erosion is that the lighter and more fertile parts of the soil are carried away by the wind, leaving the coarser sterile soil behind.

In some places where loose sandy soil has been exposed, constantly moving sand dunes are formed by the action of the wind. Good land may be covered and buildings almost buried by the relentless advance of the sand unless it is held in place by a covering of trees and shrubs.

While it is not possible to eliminate erosion completely, a great deal can be done to keep it in control and reduce its

effects to a minimum. Ideally we should take each river basin as a unit and work out a plan to combat erosion over the entire area drained by the river and its tributaries. A number of river valleys are being reclaimed in this way under the direction of River Valley Authorities (see Chapter 12).

Even when there is no over-all plan for the entire watershed, there is much that the individual farmer can do. The following are some of the methods that may be used to combat erosion.

A severe blow-sand area is pictured below. In the foreground are dunes drifted in around a barn to a depth of about 6 feet.

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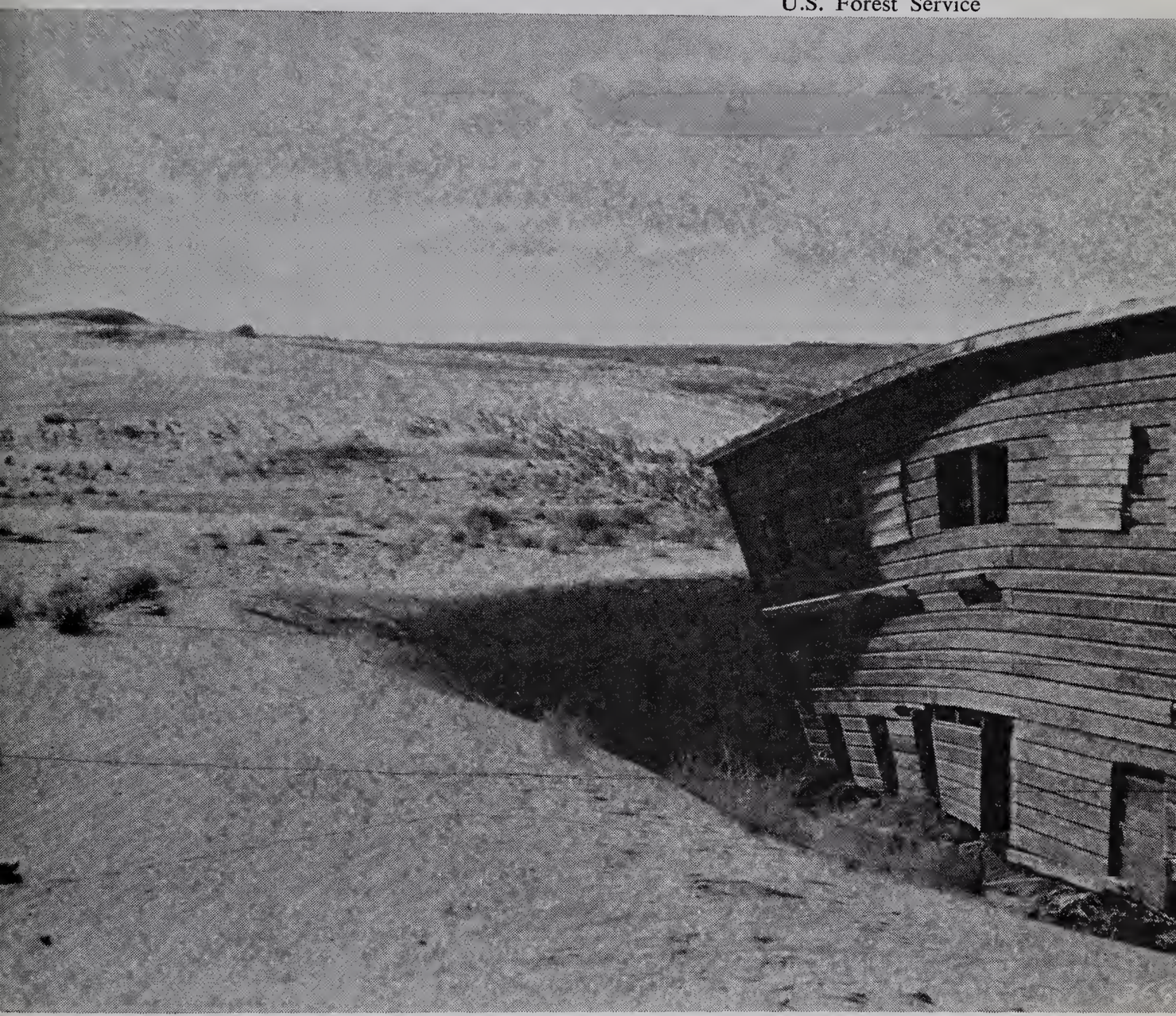

This completed contour trench is part of a small watershed project. Its purpose is to prevent too-rapid run-off and consequent erosion.

(a) Contour ploughing, which simply means ploughing at right angles to the direction in which the water tends to flow. Every furrow then becomes a dam holding back the water and giving it time to soak into the soil.

(b) Terracing, which means reshaping the slopes into a series of broad flat steps. Here again the water will tend to sink in rather than run off. There is the further advantage that flat areas are more easily worked than slopes.

(c) Strip farming is an excellent way of controlling erosion. Instead of dividing the farm into a checkerboard of rec-

U.S. Forest Service

tangular fields without regard for the slope of the land, crops are planted in strips that follow the contours across the entire farm. Grassed strips may alternate with cultivated strips to reduce still further the downhill flow of water and give it more time to soak into the soil.

(d) Steep slopes and banks should be planted with trees and fenced from livestock.

(e) Slopes that are not too abrupt may be used for moderate grazing or to produce a hay crop.

(f) Ponds may be developed to retain water and prevent loss of soil.

Wind erosion can be held in check by:

(a) "Stubble-mulch" or "trash-cover" farming. This is a system of farming whereby the stubble or residue of the previous crop is not ploughed under in the usual way, exposing the bare soil. Instead of the standard plough, an implement called a blade cultivator is used to open up the soil without removing or burying the stubble and trash. In this way moisture is conserved and the land is protected from both wind and water erosion.

(b) Crop rotation and the growing of grasses and legumes. This gives the soil more fibre and has a binding effect.

(c) Irrigation to provide moisture during dry periods.

(d) Strip cropping at right angles to the wind direction.

(e) Wind-breaks at intervals to cut down wind velocity.

To combat the serious damage by wind erosion in the great plains, the Prairie Farm Rehabilitation Act was passed by Parliament in 1935. As a result of this Act, great irrigation schemes were undertaken and money and research were directed toward improved farming methods. Five great irrigation projects that will provide abundant water for 1,500,000 acres of land have been constructed, or are in process of construction, in Alberta and Saskatchewan. The South Saskatchewan River Project alone will provide water for the irrigation of 500,000 acres of land, and the water will be used for power and recreation as well as for irrigation. Prairie farmers have been encouraged to retain water in ponds or "dug-outs", and financial assistance has been provided for this.

These projects, both great and small, have done much to reduce the danger of drought and wind erosion. In Nova Scotia, New Brunswick, and Prince Edward Island the Federal Government has provided assistance for the construction of dykes and breakwaters to protect and extend the productive soils of the coastal marshlands.

In the matter of erosion we must always keep in mind that it is better to prevent it than to cure it. Therefore, before the clearing of new land, either grassland or forest, a thorough study of it should be made to ensure that with wise handling it can be prevented from eroding.

SOME FACTS AND FIGURES

1. It has been calculated that the loss of one inch of soil from one acre of land in the black-soil belt of Alberta means the loss of 1,500 lb. of nitrogen, 300 lb. of phosphorus, and 15 lb. of organic matter. It would require 150 tons of manure to replace the lost nitrogen, and the phosphorus lost would have provided for 20 crops of wheat yielding 50 bushels to the acre.

2. It takes up to 1,000 years for nature to produce one inch of good topsoil. This much might be removed by a single torrential rain from sloping land cultivated up and down the slope.

3. Land used for grain crops such as wheat, oats, barley, and rye loses from 16 to 40 times as much soil to water erosion as woodlands and undisturbed prairies.

Strip farming helps to prevent erosion.

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4. During flood the Mississippi River carries about four and a half million tons of sediment a day into the Gulf of Mexico. This is equal to a six-inch layer of topsoil from 46 one-hundred-acre farms.

5. A deep harbour once existed where the Lincoln Memorial now stands in the city of Washington. This harbour was completely filled by sediment brought down by the Potomac River.

6. A reservoir supplying water to a power plant lost 80% of its water-holding capacity over a period of 25 years, owing to silt washed into it from the drainage area.

7. It is estimated that the world has about four billion acres of productive land from which to feed and clothe its population, and this area is steadily dwindling as a result of erosion.

8. *Material being washed into the seas by the rivers of the world:*

(a) Soil and other undissolved material:
2 billion tons per year

(b) Dissolved organic matter:
400 million tons per year

(c) Dissolved inorganic matter:
4 billion tons per year

9. Each year 3.5 million tons of phosphorus (or more correctly: 9 million tons of phosphate) are washed from the land into the seas. *Less than 3%* of this amount is returned to the land (as guano from sea birds). This will be the *first* of the essential elements to run out (if present trends continue), resulting in the death of land plants and animals.

The only "practical" method of replacing the lost phosphorus will be to await the next geological cycle of uplift that will bring phosphate rock above sea level!

(Relative weight of phosphorus in earth's crust is 0.13%; in plants, 0.2%; in man, more than 1%.)

(A corn crop of 60 bushels per acre removes 10% of the phosphorus in the upper 6 inches of fertile soil.)

QUESTIONS

1. What is meant by the statement "There are only seven inches between us and starvation"?
2. What conditions bring about (a) water erosion, (b) wind erosion?
3. Name and describe two types of water erosion.
4. Describe the damage that may be done by the depositing of silt.
5. What caused the great dust storms of the prairies? What measures are being taken now to prevent a recurrence of this?
6. What are sand dunes? How are they caused and how do they move? Describe the damage they cause and how it might be prevented.
7. How would *you* operate a farm so as to keep erosion to a minimum?
8. What is the approximate population of the world? How many acres of productive land are there per person? (See page 50, and item 7, page 58.)
9. Try the experiment with the milk bottle (p. 50) the next time you see muddy water running off a cultivated field. Compare with a sample taken from a stream running from a wooded area.
10. Look for evidence of erosion in the surrounding countryside. Take photographs to show examples of gullies, sand dunes, contour ploughing, reforestation, etc. Use for a class display.
11. List five ways of preventing erosion by water and five ways of preventing erosion by wind.

PART II: THE SOIL

11 Grasses and Legumes

Two great inventions started primitive man on the road to civilization. First came the domestication of wild animals, an invention that changed early man from a hunter to a herdsman. This naturally led to the second great invention, the cultivation of grasses, which enabled the nomads to cease their wanderings in search of pasture and become farmers. As farmers they became firmly rooted to the soil that sustained them, and learned to adapt themselves to the recurring tasks of seed time and harvest. By the cultivation of grasses, one square mile in the valley of the Nile was able to support 1000 people, whereas the primitive hunter required several square miles to provide food for *each* member of his family.

As the fear of starvation diminished, communities and cultures developed, and finally great civilizations and empires came into being. One of the Roman goddesses, Ceres, was believed to be responsible for the success or failure of the crops. From her we derive the word *cereal,* which we use to

designate our most valuable grain-producing grasses – wheat, oats, barley, rye, corn, and rice.

Grasses not only provide the human race with most of its food, but are also one of nature's greatest agencies for building and protecting the soil. In our efforts to conserve and build up soil we would do well to follow as closely as possible nature's own methods and make greater use of grasses wherever possible.

Some of our more important Canadian grasses, apart from the cereals, are the Kentucky Blue grass, the Canadian Blue grass, timothy, orchard grass, brome grass, and meadow fescue. In the prairie regions we find the hardy, drought-resistant grasses such as the buffalo grass, wheat grass, and spear grass. Associated with the grasses are the legumes, which are grown for pasture or as hay for winter feeding. Our more important legumes for this purpose are alfalfa, alsike, and bird's foot trefoil, and also the clovers such as Sweet clover, Red clover, and the giant or Ladino clover. Pasture grasses and legumes growing in association benefit one another and form an ideal combination to enrich the soil and prevent erosion. As well as being excellent soil-building plants, they provide the cheapest and probably the best feed for livestock. It would be difficult to overestimate the value of grasses and legumes in preserving and building topsoil and restoring badly eroded land. Grass roots bind the topsoil into a firm sod, while the leaves break the force of the rain and slow down the movement of water, giving it time to soak into the soil. Depressions in fields where water runs during the spring run-off and after heavy rains should be gently sloped and kept constantly in grass. Kentucky Blue grass and creeping Red Fescue are ideal for this type of grassed water-way because of their densely matted roots. The addition of low-growing legumes such as the Dutch and Ladino clovers improves still further the effectiveness of the water-way.

There are many other ways in which legumes are valuable to the farmer and to the economy of the country generally.

Alfalfa and sweet clover have roots that penetrate deep into the subsoil and bring to the surface valuable minerals that would otherwise be inaccessible to the shallow-rooted grasses. All the well known varieties of beans and peas, including soybeans, are legumes and are among our most important food plants. The earliest written records show that soybeans were cultivated in China more than 4800 years ago, but it was not till about 1908 that they were introduced into England and received world-wide attention. In North America the soybean is grown largely for its oil, which is used in the manufacture of margarine, cooking fats and oils, mayonnaise, and salad dressings. The meal residue is a valuable source of protein and is used in food preparations for animals and poultry. It is also used in the manufacture of plywood glues, emulsion paints, washable wallpaper, and other industrial products.

An extremely valuable property of leguminous plants is their ability to obtain nitrogen from the atmosphere by changing it into nitrates and other soluble forms by the action of bacteria living in swellings or *nodules* in the roots. This process is called nitrogen-fixing, and the bacteria that carry it out are called *nitrogen-fixing bacteria.* When the legumes die or are ploughed in, the nitrogen and organic matter they contain are added to the topsoil for the benefit of future crops. Ploughing-in plants of this kind is therefore one of the best and cheapest ways of improving soil and increasing crop yields. Green crops grown to be ploughed under are called "green manure".

Green manure benefits the soil in many ways. New organic matter, which the plant manufactured out of carbon dioxide and water, is added to the soil along with the nitrogen supplied by the nitrogen-fixing bacteria. Any minerals that the plant borrowed from the soil while it was growing are returned to the soil, and minerals brought up from the subsoil are added to the topsoil. For best results the green manure should be thick and luxuriant. To produce such a crop the land must be

These swellings or nodules were produced on the roots of the Austrian winter pea, a legume, by nitrogen-fixing bacteria.

U.S. Department of Agriculture

properly prepared and, if it is badly run down, essential minerals will have to be added.

On many farms, lime, phosphate, and potash are the chief needs. The soil may also be deficient in nitrogen, which can, however, be supplied by the legumes if the other minerals necessary for their growth are present. Many soils require the addition of lime because grasses and legumes do not do well under acid conditions and also because lime supplies the important element calcium. Neither the nitrogen-fixing bacteria nor the bacteria that cause decomposition of organic matter do well in acid soils; hence the addition of lime promotes the production of nitrogen and speeds up the formation of humus. Phosphate is necessary to supply the element phosphorus, which is needed in most soils and which is removed from the farm when grain or livestock are sold. Potash supplies potassium, which is another essential element; however, there are many soils that contain a good reserve of potassium, and much of it is returned to the land in barnyard manure. Potassium is not likely to be as urgently needed as phosphorus, but the extent to which any element is needed in any particular location can only be determined by soil analysis.

Worn-out land cannot be restored by simply finding out what elements are missing and then replacing them in the form of artificial fertilizer. Soils receiving no other treatment than this, year after year, are apt to become compact and incapable of holding moisture. Under these conditions plants have difficulty developing their root systems, and the minerals in the soil remain undissolved and unavailable. If, in addition to chemical fertilizer, green crops are grown and ploughed in to form humus, the soil-building process will be vastly improved, and a topsoil of excellent quality and tilth will develop.

The addition of humus to the soil helps to improve it in many ways. It soaks up and holds water like a sponge. It swells and shrinks according to the amount of moisture available, and this alternate expansion and contraction helps to keep the soil loose and granular. It prevents clay from becoming slimy and puddled when wet, and hard and cement-like

when dry, and its presence encourages the growth of soil organisms. Without these the soil is dead soil even though its chemical composition may appear satisfactory.

When a programme of soil restoration is undertaken, the land should be carefully prepared and fertilized to produce a heavy luxuriant growth of green soil-building plants. Best results are obtained if these are ploughed in while they are still soft and succulent so that they will decompose rapidly and add their substance to the soil, thereby improving both its texture and its content. In this way spectacular results have often been achieved in the restoration of land that was exhausted or eroded. After the initial expense of fertilizing the soil there should be very little further outlay, for once the process of enrichment begins, it gathers momentum and sets in motion a whole cycle of beneficial results. Erosion ceases, pastures become greener, grain crops increase their yield, the production of beef, pork, or milk is increased, and barnyard manure and straw are returned to the land.

A well-balanced system of rotation is an essential condition for the success of this kind of farming. Fields that have been used to grow grain or potatoes should be returned to grass and legumes to produce hay, pasture, or green manure before again being used for soil-depleting crops. This kind of conservation farming, sometimes called grass farming, is far superior to the short-sighted system of one-crop farming which sooner or later leads to exhaustion of the land.

A carefully worked-out plan of soil conservation based on grass-legume and livestock farming is the farmer's best insurance against decreasing production and wasted land. Conserving soil in this way insures that farming will be both profitable and *permanent*.

QUESTIONS

1. How did the cultivation of grasses help to start early man on the path to civilization?
2. What is the origin of the word *cereal*?
3. Name six cereals and six soil-building grasses that are not cereals.
4. Name six legumes grown with grasses for pasture or hay. How do legumes help to improve the soil?
5. How do grasses and legumes prevent erosion?
6. What elements are frequently lacking in the soil and how may they be restored?
7. Why is lime often used on the land?
8. What is *green manure* and how does it benefit the soil?
9. What is the value of humus in the soil?
10. What is meant by crop rotation? What are the advantages of this type of farming?

PART II: THE SOIL

12 Fred Norris

The last payment had been made and the last paper signed. Fred Norris watched the lawyer's car drive slowly down the lane; then he sat down on the low rail of the verandah feeling very satisfied with the world and particularly with the small green part of it that lay neatly spread out in the valley below. The farm had not always looked as attractive as it did today, and as Fred sat there his mind went back over the events that led to his present happy feeling of accomplishment. . . .

The time had gone by very rapidly. He could scarcely believe that it was six years now since he had taken over the farm. He remembered how everyone had advised him against it, but in spite of this he had gone ahead, for he had ideas of his own and knew what he wanted to do. He liked the location and the low price, and he was convinced that he could transform this neglected piece of land into a fertile and productive farm.

Until he came to live here, Fred's experience in farming had been very limited. He grew up in a small country town where

he spent his summers working on the neighbouring farms. Later he drifted from place to place working at various jobs, but although he was a skilled mechanic and made good wages he was not happy in this kind of work. He loved the land and the sights and sounds of the country as much as he hated the congestion and hubbub of the city. He knew that he would be much happier if he had a farm where he could work out in the fresh air under the open sky, and where he could plan and carry out ideas of his own. He saved his money, read everything he could find on the subject of farming, and finally bought this piece of land, which was far from good but was the best he could afford.

During the first year or so the farm provided very little return for the labour expended on it. It provided pasture of a sort for his small herd of shorthorn cattle, and it provided all the garden products that could be had for the expenditure of the necessary work. But Fred was working hard, enjoying his work, and learning quickly. He saved a good deal of money by overhauling and repairing the machinery he had acquired with the farm, and on several occasions he saved his neighbours both time and money by helping to repair a broken-down tractor or some other complex piece of machinery so essential to modern farming. In return the neighbours lent him implements or worked with him when he needed help. From them he learned a good deal about the practical problems of farming, but he was not inclined to adopt their methods without testing them by experiments of his own.

Since he intended to specialize in raising beef cattle, his main concern was to develop good pasture land and grow sufficient crops for winter feeding. When he acquired the farm it was a checkerboard of small fields separated by a great variety of fences – wire fences, rail fences, and even some very old fences of roots and boulders. Many of the fields were badly eroded, and where the land sloped off toward the river valley, a large gully had formed and was so deep in one place that the wire fence crossing it was suspended in mid-air.

Before long most of the fences were removed to make a few large fields that could be worked efficiently and economically. From his reading about erosion he knew that the *level* furrow was more important than the straight furrow, and that working long level strips was more economical in terms of tractor power and gasoline. The big gully was quite a problem as it cut right across his contour lines; however, he was able to fill in most of it with boulders and stumps from one of the old fences. Soil was then pushed in on top of this rough fill and seeded with a variety of grasses. This still left an ugly gash across the surface of the land, but erosion had been effectively checked and the work of healing begun.

When the contours were established the land was ploughed in long curving strips and then disked and harrowed. Analysis showed that the soil was slightly acid and that its main deficiencies were nitrogen and phosphorus. The Agricultural Representative advised him to spread agricultural lime on the land at the rate of two tons to the acre. He also recommended the application of chemical fertilizer, but pointed out that if

Ploughing under grass-legume crops helps to restore nitrogen to depleted land.

Federated Colleges, Guelph, Ontario

legumes such as clover and alfalfa were grown they would do much to restore nitrogen to the soil and it might not be necessary to use a fertilizer with a high nitrogen content. He suggested one containing nitrogen, phosphorus, and potash in the proportions 2-12-10.

To obtain up-to-date information on the subject of soil fertility and the use of fertilizer, Fred wrote to the Department of Agriculture and the Agricultural College for booklets on the subject. When he had read these he realized that there were still many things they could not tell him about his own particular piece of land, so he decided to find out some of the answers for himself. Over most of the prepared land he applied fertilizer and lime in the proportions recommended, but in certain drills he applied half the usual amount and in others one and a half times and even twice the prescribed quantity. In some plots he omitted the lime and in others he used fertilizers with different proportions of nitrogen, phosphorus, and potash. There was a considerable quantity of manure in the barnyard and this enabled him to try further experiments. Certain strips received barnyard manure and no artificial fertilizer, while other strips received various proportions of fertilizer and lime as well as manure. All these test areas were clearly marked and the details of the treatment written down in a notebook.

When the land was prepared he seeded it with a mixture made up of blue grasses, brome grass, alfalfa, red and sweet clovers, and Ladino clover. His study of the subject had convinced him that for relatively dead soil such as this the legumes (clovers and alfalfa) should be inoculated with nitrogen-fixing bacteria. He therefore obtained from the government Experimental Farm a liquid called nitro-culture with which to treat the seed before planting it. By this means he made sure that the nitrogen-producing bacteria would be present in the developing root systems. When it came to the actual seeding he could not resist experimenting with different proportions of grass, clover, and alfalfa, for he knew that this would provide

him with reliable information for future use.

Of course the whole farm could not be given over to the production of soil-building crops. One fairly large strip was used to produce a crop of oats for winter feeding, and a considerable section of the farm including the more hilly part was left untouched to serve as pasture during the first summer. As soon as the oats were harvested, a crop of winter rye was planted. This grew quickly and provided good fall pasture for the cattle. Fred retained them on this strip by the use of an electric fence while he went to work on the old pasture to prepare it for the same treatment that the other land had received.

The second year brought a great improvement to most of the farm. Nearly all the ugly scars and bare spots were gone, covered by a rich carpet of green. The cattle, who could scarcely find enough grass to keep themselves alive the previous summer, were sleek and healthy, and the old pasture was cultivated and seeded except for the steep hillsides, which were to be planted in trees.

The experimental plots revealed that the richest growth developed where barnyard manure had been used along with the chemical fertilizer. It also turned out that better results were obtained by using a higher than average proportion of alfalfa and a fertilizer with a high percentage of phosphorus. He applied this information to the rejuvenation of the old pasture, and the results the following year were truly amazing.

From this point on, the farm became a paying concern. Fred obtained good prices for his cattle and gradually increased and improved his herd. At the same time he was able to maintain the fertility of the land by a careful system of rotation and by keeping a close watch for any signs of erosion. . . .

Today, as he looked out over the farm from his seat on the verandah rail, he could scarcely tell where the gully had been. It was now only a shallow depression kept continually in grass to slow down the movement of the water after heavy rains.

Looking beyond the grassed water-way he could see the young Scotch pines covering the steep hillsides and the small pond in the hollow glinting like a mirror in the sunshine. Suddenly he remembered: he had been working at the fence that protected his young trees from the cattle when the lawyer arrived.

He got up quickly and hurried back to his job with the guilty feeling that he had been wasting valuable time.

QUESTIONS

1. Why did Fred Norris decide to buy the farm?
2. Why did he take down many of the fences?
3. How did he repair the gully? Describe what might have happened if the gully had not been repaired.
4. What are contour lines? What is meant by strip farming and what are its advantages?
5. What were the main deficiencies of the soil and how were they overcome?
6. What was the reason for trying so many experiments?
7. Why were legumes sown along with the grass? What treatment was given the legume seeds?
8. What is the purpose of a grassed water-way?
9. Why were trees planted on the steep hillsides?
10. What are the advantages of a farm pond?
11. What do you think were the main reasons why Fred Norris succeeded so well and Tom Pratt failed so badly?

PART II: THE SOIL

13 Land Use

The wise farmer is constantly planning ways to operate his farm in the most efficient way, and it is quite obvious that without planning he could not hope to succeed. In a complex society such as ours, planning the most effective use of land must be undertaken on a much larger scale than for the individual farm.

Land is needed for expanding cities, for airports and shopping plazas, for highways, railways, power lines, and pipelines. Land is needed for forests, mining developments, fruit farming, and market gardening. Land must be flooded when dams are built to store water for power or irrigation, and some land must be set aside for wild-life sanctuaries and for recreation.

As the population increases, demands for land become greater and, unless careful and far-sighted plans are made, conflicts will develop and the available land will not be used to the best advantage.

We would not undertake the building of a house without a carefully made plan. Surely the building of a country calls for the same consideration and deserves the utmost in clear thinking and careful planning. Planning on a national basis is ideal, but any large area such as a province, a county, or a river basin could serve as a unit, provided that the various units are co-ordinated in an over-all plan. Plans for land use may be considered briefly under the following headings:

1. SOILS

Until fairly recent times, farmers based their knowledge of land use on experience and tradition, and in general this method worked very well, especially in older settled countries. However, in the opening up of new land on this continent, with no tradition to guide them, settlers resorted to a process of trial and error which often led to great waste of both land and forest. In more recent times the thoughtless draining of swamps and marshes has often had disastrous results on an entire watershed. These wetlands are valuable as wild-life sanctuaries and for storing and regulating water, and should not be drained without a very careful investigation of all the possible results.

With all the facilities of the modern scientific age there is no longer any excuse for haphazard methods or improper land use. The results of research are available from many institutions in many countries, and modern agricultural colleges and experimental farms provide a wealth of information on all phases of land use. Soils can be analysed quickly and farmers given precise information about the requirements of the soil and its suitability for various crops. A very important phase of this work is the classification of soils and the construction of detailed maps showing the extent and location of each type of soil. Such maps are the basis of successful land-use planning.

The necessity for such planning is apparent when we consider that as time goes on and there are more cities, towns, and industries, we shall have to produce more food from fewer

acres.* Wherever possible we must try to retain good agricultural land for farming and good fruit-growing land for fruit growing, leaving the less productive land for highways, airports and industrial sites.

2. FORESTS

Canada has vast forest resources, but they are not inexhaustible and if their management is not carefully planned we may find it difficult to meet the requirements of the future on a continuing basis. Just as we foresee an increasing demand for agricultural produce, we can also foresee steadily increasing demands for lumber, paper, veneer, and other forest products.

The forest should be managed on much the same system as a farm, except that there is a much longer interval between one crop and the next. Systems of reseeding or replanting cut-over areas can insure a new crop at regular intervals and thus utilize the forests on a sustained-yield basis.

The mapping of forest lands is basic to such planning, just as soil maps are the basis of soil planning. The careful classification of land should prevent the clearing of good forest to produce poor agricultural land and should also indicate areas now cleared that should be replanted in trees. In many of the more settled parts of Canada the reforestation of unproductive land would do a great deal to restore the natural water balance and reduce both flood damage and erosion. Reforestation also helps in the development of wildlife sanctuaries and recreational areas not too far away from the centres of population.

3. URBAN

The rapid expansion of cities, towns, and industries in our more thickly populated areas has led to a good deal of conflict between rural and urban use of land. In cases where an over-

* The Senate Committee on Land Use reports that land is being lost at the rate of 382 acres per 1,000 population increase around many of our larger cities.

Armour Landry

The tremendous increase in road and highway traffic has led to the construction of complicated interchanges outside major cities across Canada, such as this one outside Montreal.

all plan is lacking, suburbs spread out indiscriminately in patchy areas and there is often an unnecessary waste of good agricultural land. At the same time problems arise in connection with traffic congestion, water supply, and sewage disposal. In the Niagara peninsula, for example, large areas are going out of fruit production in favour of industrial and residential uses. This area has a unique combination of soil, climate and water which makes it ideal for fruit growing. It is also ideally situated for industrial development, so that conflict is bound to occur. Similar situations exist in many of our more densely populated areas, but those who have studied the subject believe

that with co-operation and careful planning we can retain the best of the specialized agricultural lands and still allow for urban and industrial expansion.

Taxation and land values are major topics to be considered here, for it is difficult to retain land in agricultural use near a town or city if taxes or land values become too high. In such cases land will likely be sold for housing developments and the unplanned urban sprawl will continue.

Many problems have to be considered in connection with the zoning of land for special purposes, developing fair systems of taxation, and enacting the necessary by-laws. In some cases Regional Planning Boards have been set up to try to resolve the conflicts that arise, and to devise the best over-all plan for the area.

4. TRANSPORTATION

Communication routes have always had a very great effect on land use. Water-ways, our oldest form of communication, determined the routes of the explorers and the location of early settlements. Water-ways still determine to a large extent the location of population centres. For example, the St. Lawrence Seaway has already had a tremendous effect on the development of ports, cities, and industries.

Railways have had the effect of opening up new areas and facilitating the transportation of products of mine and farm to the seaports and industrial regions. Now the emphasis is on highway construction, and new areas are constantly being made accessible to the public as the network of roads extends in every direction.

Wherever new roads are built, land values increase, agricultural development is stimulated, and new towns and industries spring up. This means that great responsibility rests on the road planners to consider the long-term effect of land use that will follow the building of a new highway along a particular route. We must also consider that the modern trunk highway with its boulevards, access roads, clover-leaf junctions, and

wide landscaped borders occupies a very considerable area of what might have been productive agricultural land. Many of these things must also be considered with regard to the routes taken by gas and oil pipelines and electric power lines.

Airports are becoming increasingly important, and suitable land convenient to densely populated centres is very often difficult to find. It is important, therefore, that such areas be selected and controlled far in advance of suburban growth. Airports may be as important in the future in determining the location of cities and trade routes as seaports were in the past.

5. RECREATION

All forecasts for the future indicate that people are going to have more leisure time, and it is important that a considerable portion of this time should be spent in outdoor recreation. It is apparent that in many densely populated areas not enough consideration has been given to the establishment of parks and green-belt areas where people can find healthful relaxation. In many cities, lakeshore areas that might have been developed into beaches and parks have been taken up by industrial plants and railways, and sometimes people have to travel several hundred miles to find conditions that provide them with the kind of relaxation they desire.

One of the most urgent needs at the present time is for the development of many small parks within easy reach of our large cities. Such parks can serve many more people than the large national and provincial parks that can only be reached after many hours of driving. Parks of this kind would also do much to attract visitors to our country. Tourists spend about 350 million dollars in Canada annually and there are predictions that this may grow to one billion dollars in the next 20 to 25 years.

It has been estimated that for every 1,000 people there should be a recreational area of about ten acres within a distance of an hour's drive. The most careful planning will be needed if such areas are to be developed in the face of com-

petition from all other sources for the available land.

In a democracy this planning must come from discussion and agreement among the citizens, the experts, and the representatives of government and industry.

The success of our planning depends on how accurately we can predict the result of certain actions and also upon the thoroughness with which the factors have been considered. Sometimes experts in a particular field become so specialized that they fail to see the over-all picture, and while they understand certain things very well, they may overlook other critical factors that ultimately bring their plans to ruin.

Good planning should lead to the wisest use of land both for the individual and for the whole of society, and it should do this without unjust restrictions on individual freedom.

QUESTIONS

1. What are soil maps and why are they important?
2. Should all swamps and marshes be drained to provide more land? Explain.
3. What is meant by utilizing the forest on a "sustained-yield" basis? In what country (or countries) of the world is this done now?
4. Why do conflicts about land use develop in densely populated areas? Give some examples.
5. How are land uses affected by (i) the building of highways, (ii) the construction of airports, (iii) the distribution of pipelines and power lines?
6. What land-use plans should be made in city and suburban regions to provide space for recreation?

If we think of it as the source of all the changefulness and beauty which we have seen in the clouds; then as the instrument by which the earth we have contemplated was modelled into symmetry, and its crags chiselled into grace; then as, in the form of snow, it robes the mountains it has made, with that transcendent light which we could not have conceived if we had not seen; then as it exists in the foam of the torrent, in the iris which spans it, in the morning mist which rises from it, in the deep crystalline pools which mirror its hanging shore, in the broad lake and glancing river, finally, in that which is to all human minds the best emblem of unwearied, unconquerable power, the wild, various, fantastic, tameless unity of the sea; what shall we compare to this mighty, this universal element, for glory and for beauty? or how shall we follow its eternal cheerfulness of feeling? It is like trying to paint a soul.

– RUSKIN

PART III: WATER

14 The Indispensable Liquid

In ancient times people believed that life depended upon four main "elements" – fire, earth, air, and water. In a sense they were right, for sunlight, soil, air, and water are the four things most essential to life, and without any one of them life would cease to exist on the earth. We have relatively little control over sunlight and air, but the soil and water are gifts that nature has entrusted to our keeping, and it is our responsibility to use them wisely.

We use enormous quantities of water in our everyday life, a fact we do not usually realize until there is a water shortage. If we consider all the water used in the laundry, bathroom, and kitchen, and the water used in washing the car and sprinkling the lawn, and add to this the water used by the municipality for such purposes as street-cleaning and fire-fighting, we find it averages about 120 gallons per person every day. In some large industrial cities more than 200 gallons are used per person per day, and the amount is steadily rising.

Besides this direct use of water, almost every product we use requires a great deal of water during its manufacture. For example, about 65,000 gallons of water are used in the production of one ton of steel, and about 50,000 gallons for the production of one ton of paper.

Water enters very largely into the composition of all living things. Our own bodies are about 70% water, and most of our foods have a very high water content; for example, milk is 87% water, vegetables vary from 80% to 97% water, and meat and eggs are from 60% to 65% water.

Water is sometimes called the universal solvent because it can dissolve more substances than any other liquid. But more important than this is the fact that it can dissolve those substances that must be carried in solution into the roots of plants. In animals it dissolves the final products of digestion that must be carried through the walls of the intestine and delivered to the bloodstream for distribution to all parts of the body. For this reason large quantities of water must circulate continually through the bodies of both plants and animals. It has been calculated that a plant uses between 300 and 600 pounds of water in the production of one pound of dry matter. In producing a crop of grain, about 650,000 gallons of water are required per acre of land, and in a single day an acre of lush grass transfers about six tons of water from the soil to the air. The average person loses about a pint and a half of water a day through perspiration which he does not even notice, and of course if he takes vigorous exercise the amount is greatly increased. The evaporation of perspiration from our bodies has a cooling effect and has a great deal to do with keeping our bodies at a constant temperature. One reason why we feel uncomfortable in humid or "muggy" weather is that evaporation is slowed down and our temperature-regulating mechanism is not able to function properly.

Water not only dissolves and transports raw materials, foods, wastes, and other important substances in plant and animal bodies but it also dissolves gases, and in this way carries oxygen from the atmosphere to the gills of fish, and

ammonia from the atmosphere to the soil. Without water, decay could not take place, and as was pointed out in Chapter 8 decay allows the same essential materials to be used over and over again in an endless cycle.

Water itself follows an endless cycle called the water cycle or the hydrologic cycle. Sometimes it is a solid (ice), sometimes a liquid, and when it evaporates into the air it becomes an invisible gas or vapour. Clouds, fogs, and mists are not gases but are composed of millions of tiny liquid droplets. This endless cycle of water was known to ancient thinkers, for in the book of Ecclesiastes we find it described in these words: "All the rivers run into the sea; yet the sea is not full; onto the place from whence the rivers come, thither they return again."

The power of moving water has been recognized and harnessed since early times. In pioneer days the fast-flowing water of "the old mill stream" turned the wooden water-wheel and provided power for the grinding of grain. Since then the scientific development of our great water-power resources has been one of the greatest factors in the growth of our nation. Without plenty of cheap electric power we would not have been able to develop our mineral or forest resources or to manufacture the products made from these resources. Hydro-electric power, by making possible the expansion of industry, has provided employment and increased the prosperity of each individual. Cheap electric power, available in cities, towns and villages, and on a large number of farms, makes possible the use of many labour-saving devices and is one of the main reasons for our present high standard of living.

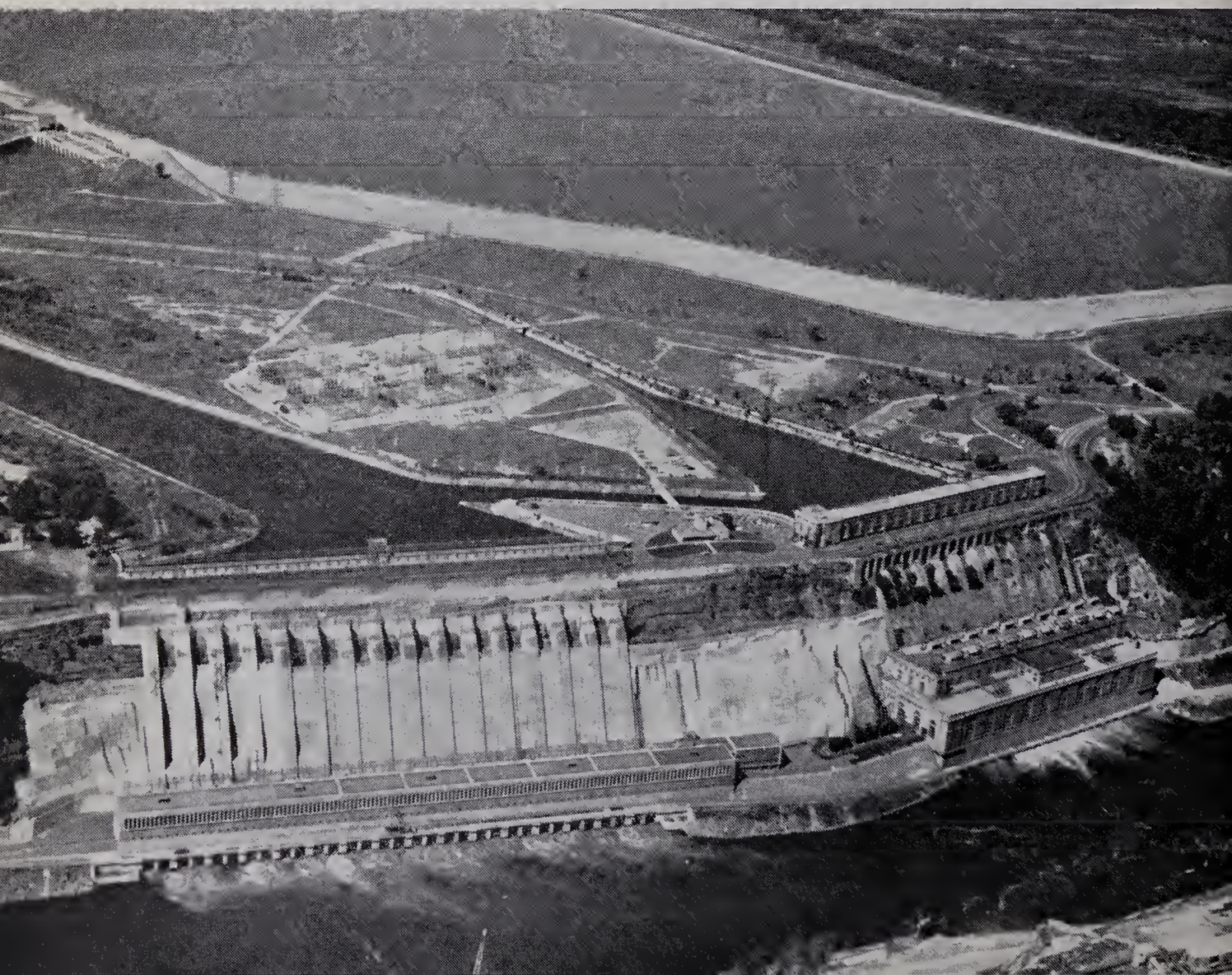
The United States is the only country producing more hydro-electric power than Canada. However, the quantity of power available *per person* in Canada is greater than in the United States. Canadian power is also less expensive.

Quebec is the richest of the Canadian provinces in both developed and undeveloped power resources. Almost half the electric power produced in Canada is produced in Quebec. Great power plants are located on the St. Lawrence River, the

Saguenay River, the St. Maurice River, and many more. Ontario has large water-power resources and ranks second among the provinces in power production. It has great power plants on the Niagara, the St. Lawrence, and the Ottawa rivers, and many other plants both large and small throughout the province. British Columbia has many fast-flowing rivers and vast water-power resources. The great power plant at Kemano supplies power for the Aluminum Company of Canada and the community of Kitimat. There are many other developments in the southern part of the province and many excellent sites to be developed as the need arises. Manitoba has large water-power resources in the Saskatchewan, Nelson, and Churchill rivers but most of the power plants developed so far are on the Winnipeg River. From these the power is transmitted to Winnipeg and to about 500 cities, towns, and villages, and to most of the farms of the province. Saskat-

Ontario Hydro's Sir Adam Beck–Niagara Generating Stations 1 and 2 are in the foreground. In the background is the reservoir for the pumped-storage development.

Ontario Hydro



chewan's hydro-electric power developments are mainly in the northern mining areas. However, a large hydro-electric generating plant is coming into operation as part of the South Saskatchewan River Project, which also includes a large-scale irrigation project. In Alberta large hydro-electric power plants are located on the Bow River and its tributaries, and there are many good power sites in other parts of the province. In Newfoundland, Nova Scotia, and New Brunswick water-power resources are small in comparison with the other provinces, but moderate-sized power plants are numerous, and convenient to centres of population. Great water-power resources are available in Labrador, but it has not been found advisable to develop these at the present time.

Studies are now being made with a view to the development of a national power grid system. Such a national grid would involve a network of transmission lines connecting all the main sources of electric power and all the principal areas of use, so that power could be switched from one region to another as needed. This would allow a great deal of flexibility and economy in the use of electric power.

Besides providing us with cheap and abundant power, our water-ways have another value not so easily measured: that of providing pleasure and recreation for ourselves and for the tourists who visit our country.

Modern industry, which often demands tense or tedious work under unwholesome conditions, also provides us with increased leisure and has literally paved the way to the cool woods and refreshing lakes. Canada has immense areas of lakes, streams, and mountains, encompassed everywhere by forests, where conditions are ideal for sport or relaxation. Where the damselflies dart among the water-lilies and the turtle suns himself on a driftwood log, where shoals of minnows cruise along the shore and the kingfisher flits from tree to tree, there we find so much of beauty and interest that we forget the cares and worries of everyday life.

Many visitors come to Canada every year to hunt or fish,

or simply to find relaxation and refreshment among scenes of unsurpassed natural beauty. Tourist travel, in fact, has become one of Canada's major industries. About $350,000,000 is spent each year by visitors to Canada, most of whom are from the United States. Some of this money goes directly to the government as taxes on items such as gasoline, but most of it is widely distributed and redistributed through all the channels of commerce in the country.

In considering the conservation of our water resources we should not overlook the immense value of swamps and marshes in retaining water and distributing it gradually to the surrounding areas. This is especially important where the land has been deforested and is no longer able to retain much of the moisture that falls upon it. In the swamp or marsh the snow melts slowly in the spring, and since the ground is very spongy it retains huge quantities of water, which it gradually feeds to the surrounding areas. In this way the water-table is kept at a high level many miles from the swamp, and wells are kept full that would otherwise run dry.

The government has gone to great expense to establish and supervise forest preserves and wild-life sanctuaries. Swampy and marshy areas, like islands in a sea of plough furrows, serve the same purpose. Often they are a last refuge for muskrats, beavers, and other aquatic animals. They also abound with small forms of life such as frogs, minnows, insects, and snails, which provide food for aquatic birds. These wetlands are the favourite hunting-grounds of the bittern and the great blue heron. Here come wild-fowl – the ducks and the geese – to rest and "refuel" on the way to their breeding-grounds in the far north. Swamps at the mouths of rivers or bordering lakes provide ideal spawning- and feeding-grounds for fish such as pike, maskinonge, and large-mouthed black bass.

The important function of these lands is not widely realized and it is doubtful if their role in the general economy of the country has been sufficiently studied. This is evidenced by the

fact that many swamps have been drained, with disastrous results to the surrounding land. Such draining is seldom advisable from the long viewpoint. The immediate gain is usually small and the eventual damage is inestimable.

It is not suggested that the draining of wetlands is not beneficial in some cases, but before any action is taken a careful survey of the whole situation should be made and *all* the consequences taken into account. A marsh should not be drained in the interests of one person or a small group of people if it means the destruction of an important wild-life sanctuary or if it is likely to affect the wells and soil water within a radius of 20 miles or more.

QUESTIONS

1. What were the four "elements" of ancient times? How many elements do chemists recognize today?
2. Approximately how many gallons of water are used per person per day for all purposes?
3. What is the percentage of water in (a) the human body, (b) milk, (c) vegetables?
4. Name some foods that can be preserved by removing the water. Why do they not decay?
5. How much water does a plant require to produce a pound of dry matter?
6. Explain what is meant by "the water cycle".
7. Which province has the greatest water-power resources? What would be the advantages of a power grid?
8. Give the location of the main hydro-electric power plants in your own province.
9. Name two places where aluminum is produced in Canada. Why were these locations chosen?
10. Why do so many tourists come to Canada? Approximately how much money do they spend?
11. Explain how swamps and marshes serve a useful purpose (a) in the conservation of water, (b) in the conservation of wild-life.
12. What information should be obtained before a swamp or marsh is drained?

Ontario Department of Travel and Publicity

Canada is lake country, particularly that portion lying within the Canadian Shield. Between Lake Superior and Lake Winnipeg there is almost as much water as land – in a mapped area of 6,000 square miles there are more than 3,000 lakes.

PART III: WATER

15 "Water, Water, Everywhere . . ."

The earth is a watery globe. If it were not for the irregularities of its surface it would be covered everywhere by water to a depth of about 9,000 feet. As it is, the oceans cover roughly three-quarters of the earth, averaging two miles in depth, while the land that projects above the water has an average height of only half a mile. Besides this, many land areas contain within themselves considerable quantities of fresh water in the form of lakes. Sections of northern Ontario, for example, are about half land and half water.

In view of these facts it must seem strange that many communities are finding it difficult to obtain the water they need. We are reminded of the plight of the Ancient Mariner becalmed in the silent sea with "water, water, everywhere, nor any drop to drink".

Water, as you know, follows an endless cycle – evaporating, forming clouds, falling as rain or snow, finding its way into the soil and into the body of every living thing, then back to

the lakes and oceans to start the process all over again. Under natural conditions the water that fell on the land found its way back to the lakes and oceans in a very leisurely fashion, but human interference has greatly disturbed and accelerated this part of the water cycle, with the result that many serious problems have arisen. One of these problems is erosion, which was dealt with in Chapter 10. Other problems experienced by many communities are spring floods, water shortage, silted reservoirs, polluted water, or a combination of all of these.

The trouble began when the natural cover, either grass or forest, was removed from the land. Grass breaks the force of the raindrops and holds the water long enough to let it soak into the ground (Chapter 11). Forests also protect the soil in many ways. The leaves break the force of the rain and allow it to drip gently onto the forest floor where it is quickly soaked up by the porous leaf-mould. The tree roots bind the soil and hold it firmly so that even on steep hillsides there is little danger of erosion. Where there is no forest to protect it from the sun, the snow melts suddenly in the spring and the rivers become muddy torrents, overflowing their banks and causing disastrous floods. Later on there is not enough water because it did not sink into the ground to be released gradually during the dry season. As a result springs and wells dry up in late summer, and the rivers, which were raging torrents in the spring, are reduced to tiny streams of water trickling among the weeds and stones of the river bed.

It is obvious that under such conditions very few fish or other forms of aquatic life can survive. During the period of flood the river bed is scoured, spawning-grounds of fish are destroyed, and the small forms of aquatic life that serve as fish food are either smothered in sediment or washed away. When summer comes the small trickle of water that remains becomes so hot that it can scarcely hold any oxygen, and fish must have oxygen to survive.

Added to all these problems is the problem of pollution, for

with the growth of population, our rivers and lakes are called upon more and more to receive both domestic sewage and industrial wastes.

It is very easy to deplore and condemn pollution, but we are all offenders in this respect and there is no easy solution to the problem. Laws have been passed since pollution first became a serious problem, but it is not a matter that can be corrected simply by passing a law. One of the first laws con-

This photograph shows an example of the damage that may result from spring flooding.

Ontario Department of Lands and Forests

cerning pollution was passed in England in 1612. It said in part:

> Wee doe by these presents for us our heirs and Successors straightly charge and command all person and persons whatsoever That they or anie of them doe not hereafter cast or putt into the said New river anie earth rubbish sayle gravell stones dogges Catts or any Cattle Carrion or anie unwholsome or unclean thing nor shall wash nor clense anie clothes wool or other thinge in said river . . .

In spite of this law and all the laws that have been passed since, the quantity of wastes discharged into our water-ways has steadily increased. It would be absurd to pass, or try to enforce, a law that stated that no waste of any kind could be deposited in any body of water. Most of these wastes have to be discharged somewhere, and we must keep in mind that one of water's chief uses to man is as a cleanser, a solvent, and a conveyor of wastes. Laws, however, must be provided and enforced to prevent irresponsible or unnecessary pollution, and to make sure that every effort is made to keep wastes to a minimum and reduce their ill effects by the best methods available.

Water has a great ability to decompose waste material and change it into useful elements, provided there is a large enough body of water and plenty of oxygen is present. Problems arise when excessive quantities of industrial waste or untreated sewage are discharged into a small volume of water, or when infection is allowed to spread to drinking-water, or when poisonous chemicals are released that quickly kill fish and other forms of life. Bathing-beaches have been ruined and great numbers of wild ducks and other waterfowl destroyed by the dumping of oil.

In many cases wastes can be treated to render them harmless before discharging them into the water. Sewage-disposal plants when properly designed and operated can change the sewage of cities and towns to a harmless liquid, but plants such as these are very costly and there are still many places

where raw sewage is discharged into the receiving water. Again the matter cannot be solved simply by making laws. The cost is sometimes too great for a municipality to bear, and many problems involving taxation, loans, and government assistance have to be worked out. However, considerable progress is being made in this direction and it is hoped that before long it will be possible to demand that every community provide for the necessary treatment, so that all sewage will be rendered harmless by the time it enters the water.

In recent years problems have arisen in the treatment of domestic wastes because of the extensive use of synthetic detergents. Such substances cause foaming and are difficult to remove from water by the conventional methods of sewage treatment. As a consequence their concentration is increasing in the receiving waters and they may even return to the householder as a constituent of his drinking-water.

Apart from such complicating factors, the treatment of domestic sewage is well understood, and plants and equipment are fairly well standardized. It is quite the opposite in the case of industrial wastes. Each industry has a different problem, and with industrial expansion and the development of new industries the problems of waste disposal are becoming more numerous and more complex.

In some industries no satisfactory way is known to eliminate the waste, while in others a form of treatment may be known but not used because of the expense. Forcing a company to use an extremely costly treatment system could easily make it impossible for it to operate at all. On the other hand, some industries by careful planning and research have found ways of keeping their waste to a minimum and neutralizing its ill effects before it enters the receiving water.

A great deal of research is needed to discover the best methods of disposing of industrial wastes and reducing their harmful effects. Governments, both national and provincial, are promoting such studies, and many industries are contributing a great deal by research efforts of their own. In some cases

similar industries have joined together to establish research laboratories in an effort to discover a solution to their pollution problems. The disposal of atomic wastes presents a very grave problem and one that may become more serious as additional plants are built for research or power production.

In spite of all the efforts that are being made to combat the menace of pollution, there are still too many irresponsible individuals and companies who give no thought to the problem, and are merely concerned with getting rid of waste in the cheapest possible way. Such persons should be required by law to make the necessary changes, and should be checked by rigid inspection to make sure that they do. In many cases, people who fish from ice huts during the winter months leave garbage of all kinds strewn on the ice. As well as adding to the problem of pollution, many of the abandoned objects such as pieces of timber, gasoline cans, or bottles float around after the thaw and become a menace to boats and water skiers. Bottles washed up on shore are broken into jagged pieces that often cause serious injury to bathers.

Bound up with the problem of pollution is the purification of drinking-water, for, unpleasant as it may seem, many cities draw their drinking-water from the same body of water into which their wastes are discharged. In the case of the Great Lakes this may not seem too serious a problem, but where a small body of water is the only one available, or where a river passes through several cities on its course, great difficulties are bound to arise. In fact, disposing of wastes and at the same time providing sufficient pure water for all household and industrial uses is one of the greatest problems a growing community has to face.

One of the most interesting developments in recent years is a method of obtaining fresh water from salt water. When this process becomes more highly perfected and the cost becomes less, it is likely to have a tremendous effect on the well-being of people everywhere. Fresh water is already being extracted from salt water at the rate of over 20 million gallons per day.

In the desert country of Kuwait a plant is producing 17 million gallons a week from the salty Persian Gulf, and several plants are operating successfully in Texas, California, Arizona, and other regions where fresh water is in short supply. In some places the cost is already as low as one dollar per thousand gallons, and continual efforts are being made to increase the efficiency of the plants and reduce the cost still further.

Another very interesting development is the attempt to bring underground water to the surface in desert regions by using the energy of the sun's rays. If the heat of the sun can be made to operate pumps that keep irrigation water flowing, many a desert could become as productive as our own wheat-lands.

When we consider that food shortage is usually the result of water shortage we can understand something of the importance of these developments. A recent report of the U.S. Senate stated:

> "If we can develop low-cost means of bringing water to the thirsty lands and people of the world, we shall bring a boon to mankind that is even more meaningful than the conquest of outer space."

QUESTIONS

1. What kind of creatures would inhabit the earth if it were a perfect sphere? Explain.
2. Why do many rivers flood in spring and become very small in late summer?
3. How do these variations in the river affect fish and other forms of aquatic life?
4. What are the two main sources of water pollution? Which is more difficult to treat? Why?
5. What becomes of the polluting substances eventually? Under what circumstances is pollution of water most serious? least serious?
6. Could we solve the problem of pollution by passing a law to prohibit it in any form? Explain.
7. What is being done by government and industry to solve the problem? What can be done by individuals?
8. Why must we be extremely careful about the disposal of atomic wastes? Find out how this is being done.
9. Where does the drinking-water that supplies your home come from? Is there a possibility of the source being polluted? What precautions are taken?
10. Describe two recent developments that may help to prevent a fresh-water shortage in the future.

PART III: WATER

16 Fisheries

Canada's great marine and freshwater fishing areas are among the nation's most valuable natural resources. Historically the fisheries played a great part in the discovery and exploration of the waters of the western world. When John Cabot returned to England after his voyage of 1497 he reported that off the coast of the New Found Land the ocean teemed with fish. "That sea", he said, "is covered with fishes which are caught not only with the net but with baskets." As a result of this information several voyages were made by European sailors to the fishing-banks off Newfoundland, and finally, in 1534, Cartier sailed on through the Straits of Belle Isle and discovered the gateway to Canada.

It is not surprising that the fishing industry was a mainstay in the early days of colonization, and although it is relatively less important now it still provides a livelihood for about 80,000 fishermen and thousands of other people engaged in the business of processing, transporting, and marketing the

harvest of the seas. Canada is the only country in the world bordering on three different oceans – the Atlantic, the Pacific, and the Arctic. The coastline, including that of the islands, totals over 60,000 miles, and off these coasts lie the greatest fishing resources of the world. Our annual commercial catch amounts to about a million tons, about 90% of which is exported. It has a total value of close to $200,000,000.

The catch is made up of about 150 different species of fish and shellfish. Some of these, such as cod, haddock, and flatfish, are valuable because of their great abundance, and others, such as salmon and lobster, are valuable because they are in great demand. Different types of fish require different conditions, and there are therefore fairly definite locations where

Fishermen haul a cod trap off the coast of Newfoundland.

Nova Scotia Film Bureau

each kind of fish is most likely to be found. Commercial fish are usually classified under six main headings: the ground-fish, the salmon, the herring, the Pacific halibut, the Atlantic lobster, and the freshwater fish.

The ground-fish include cod, haddock, hake, pollock, plaice, and flounder. These fish live close to the bottom in fairly shallow water and large catches are made in the Gulf of the St. Lawrence, on the banks east of Nova Scotia, the Grand Bank and north to Hamilton Inlet Bank, and in the coastal waters, particularly off Newfoundland. Ground-fish, especially the various types of flat-fish and cod, are also a valuable part of the fisheries of the Pacific coast.

The most important *salmon fisheries* are on the Pacific coast. Here are found the sockeye, the pink, the chum, the coho, and the spring salmon, all of which are in great demand both for export and for our own markets. Salmon spawn in freshwater streams and the young spend part of their lives in streams and rivers before migrating to the sea. When they reach maturity they return from the sea to spawn in the streams of their origin, and it is then, as the salmon approach the river mouths, that the fishermen make their catches. The sockeye is the most highly prized of the Pacific salmon because it retains its colour better than the other types when canned. Most of the salmon is canned, although some is marketed fresh or frozen. Atlantic salmon are similar in habit to those of the Pacific. They also are caught as they return to the coastal streams to spawn.

Great quantities of *herring* are caught in Passamaquoddy Bay and Chaleur Bay in New Brunswick, and in the Bay of Islands and Fortune Bay in Newfoundland. Most of the Pacific herring are caught along the coast of Vancouver Island and in the coastal waters north to the Queen Charlotte Islands. The *Pacific halibut,* a very important item of the west-coast fishery, is taken in large quantities in the same general area.

Lobster fishing is the greatest source of income to the fishermen of the Maritime Provinces. It is a business that has

to be very carefully regulated by the fisheries authorities, since over-fishing or fishing during the spawning season could bring disaster to the industry.

Most *freshwater commercial fishing* takes place in the Great Lakes, Lake Winnipeg, Lesser Slave Lake, Great Slave Lake, and a number of other large lakes and rivers. Some of the species caught are whitefish, lake trout, pickerel, perch, cisco, and sturgeon.

The type of equipment used in fishing depends on the species of fish and on the nature of the fishing-ground. Many species of ground-fish are caught by fishermen using otter-trawlers. Trap nets are used for inshore runs of cod and also to some extent for salmon. Purse-seines and gill nets are also used for salmon, while the Pacific halibut is usually taken on line gear and troll. Lobsters are taken in baited traps or "lobster pots" which are a familiar sight in the Maritime Provinces. Freshwater fish are usually taken with trap nets or gill nets.

No matter how great the fishing resources are they cannot be considered inexhaustible, and as improvements are made in the methods of catching fish the danger of over-fishing becomes more serious. The conservation and development of the marine fisheries is the concern of the federal Department of Fisheries. Freshwater fishing, on the other hand, is a matter for the provincial governments. The federal government has established a scientific branch of the Department of Fisheries called The Fisheries Research Board of Canada. Biologists and technicians employed by the Board are continually involved in research with regard to the processing, preservation, and transportation of fish and fish products. They are also engaged in studies concerning the life history, feeding habits, and diseases of the various species of fish so that sensible regulations can be made to control the industry in its own best interest. In co-operation with other countries Canada shares in the management of the northern seal herds and the deep-sea fisheries.

British Columbia Government

In addition to its commercial value, fishing in Canada is important to the tourist trade. These fish were caught off Vancouver Island.

GAME FISHING

Besides the great commercial fisheries, Canada possesses, both in its coastal and in its inland waters, many of the world's finest game fish. Sportsmen from all over the world come to pit their skill against these wary, hard-fighting fish, and it would be difficult to estimate their value both as a tourist attraction and as a source of healthful recreation. The great extent of our cool inland waters in their setting of mountain

and forest makes it possible for us to provide fishing to suit every taste.

Fishing is a universal sport and one in which everyone can participate. Izaak Walton claims that it owes its popularity to the fact that it provides the opportunity for both activity and contemplation. "The rivers", he says, "and the inhabitants of the watery element were made for wise men to contemplate and fools to pass by without consideration."

In rivers that flow down to the sea, salmon fishing is the favourite sport, while further inland the various types of trout are in great demand. The speckled trout and rainbow trout provide excellent sport in the eastern provinces, and in the west the Kamloops and cut-throat trout are held in very high regard. Other highly prized game fish are the black bass, the maskinonge, the lake trout, the pickerel, and the pike.

With the rapid growth of population, the expansion of industry, the building of good roads, and the great influx of tourists, it is obvious that the conservation of our game-fish resources should be a matter of great concern. Lakes and streams that are easily reached are likely to be greatly overfished and may also be polluted, and lakes that used to be difficult to reach are now easily accessible by airplane.

Although the importance of conserving game fish is generally recognized, there is a great deal of misunderstanding about how it should be carried out. Many people think that the planting of small hatchery-bred fish is all that is necessary to maintain good fishing, and this belief has had the effect of discouraging more constructive conservation measures that might have been undertaken.

No species of fish can thrive in the absence of conditions suitable to that species, and it should be apparent that where the water temperature in a lake has become too hot or where the natural food has disappeared, nothing can be gained by planting it with small fish. The same is true of streams that are swollen with muddy water in the spring and reduced to a trickle of warm water in the summer. Where a desirable type

of game fish is present in a lake but not very abundant, the attempt is often made to increase the numbers by planting thousands of fry or fingerlings of the same species. In this case it is probable that the lake is already supporting all the fish that it is capable of supporting, and the addition of many small fish will have little effect other than that of providing some food for the larger ones. If they were not held in check by lack of food or some similar cause, the fish already in the lake would naturally increase rapidly. It is therefore some condition of the environment that should be corrected, and repeated planting with artificially reared fish is both unnecessary and wasteful. Experiments carried out by the Fisheries Research Board indicated that the artificial propagation of salmon was having little or no effect. As a result the salmon hatcheries of British Columbia were closed and no unfavourable results have followed.

In a few cases hatchery-reared fish may serve a useful purpose. They may be used to maintain game fish in a lake that is suitable in most respects but does not have the right conditions for natural spawning, or to introduce a desirable species into waters where it does not naturally occur. However, in all such cases the planting should be preceded by a thorough study of the whole situation.

Good conservation measures include wise regulations regarding fishing seasons, catch limits, and other restrictions, as well as methods of improving the fishing by improving the environmental conditions. Some of the environmental conditions that should be corrected are:

1. EXCESSIVE DEFORESTATION

Deforestation causes rivers to flood in spring and to almost dry up in late summer. Spawning-grounds and fish food are either swept away or buried in silt, and the water temperature becomes too hot for game fish to survive. The solution, of course, is reforestation, especially at the headwaters of streams and rivers.

2. LACK OF MINERALS ESSENTIAL FOR PLANT LIFE

The productive capacity of a body of water depends upon the amount of food it can produce. Since animals depend upon plants for their food, it is apparent that if a lake does not contain the minerals that plants require, very little life of any kind can be sustained in it. The carrying capacity of lakes and ponds may be increased by the judicious use of fertilizer, just as the carrying capacity of pasture land may be increased by fertilizing the soil.

3. POLLUTION

It is obvious that fish cannot survive if the water is poisoned or its oxygen removed by the rotting of waste materials. While the remedy seems obvious, it is not easy to apply in a country where both population and industry are expanding. This topic is discussed in more detail in Chapter 29.

4. LACK OF SHELTER

Shelter is just as important to fish as it is to deer or partridge. Fish will therefore avoid parts of a stream that have been dredged or cleared of all natural protection. The same is true of lakes and ponds where there are no weed beds, rocks, or logs, and where the surrounding forest has been removed. Good results have been obtained by restoring the natural conditions as nearly as possible.

5. COARSE FISH

Sometimes a lake contains an excessive number of coarse fish. These may consume the eggs or fry of the game fish or they may consume too much of the available food. The numbers of coarse fish can often be reduced by netting, but in extreme cases all the fish in the lake may be killed with a poison called *rotenone* in order to restock with the desirable species.

6. CHANGING WATER LEVELS

When dams are installed in a water system the lake levels may be raised at one season of the year and lowered at another.

Great destruction can be caused by lowering the water after bass or other fish have spawned in the shallows.

7. OBSTRUCTING OR ASSISTING MIGRATION

The installation of dams and power plants may prevent the migration of fish to their spawning-grounds. Sometimes "fish ladders" are installed, but there are still too many obstructions not properly equipped to take care of fish migration. On the other hand the removal of *natural* barriers has often caused serious complications; for example the building of canals made it possible for the lamprey to reach the upper Great Lakes (see Chapter 27).

The wise management of our fishing resources consists largely of making sure that the environmental conditions are satisfactory and that sufficient breeding stock are present and unmolested during the breeding season. This is easy to say, but there are a great many difficulties to be overcome and problems to be solved before we can put it into effect. One of the difficulties is lack of knowledge, and a great deal of research will have to be carried out before we can solve many of the problems that need to be solved.

QUESTIONS

1. Approximately how many tons of fish are caught annually by our commercial fishermen? What proportion of this is exported and what is its total value?
2. Name the six main groups of commercial fish and give examples of each.
3. Describe the various types of equipment used by commercial fishermen.
4. What kind of work is carried out by the Fisheries Research Board and by provincial research laboratories?
5. Can good fishing be maintained by planting great numbers of hatchery fish? Explain.
6. Under what circumstances would the planting of hatchery fish be advisable? Why should a thorough biological study be made before fish are planted?
7. What are some of the environmental conditions that need correcting if we are to conserve our game-fish resources?
8. Why do some lakes and ponds require the addition of fertilizer?
9. What effect does excessive deforestation have on the habitat of game fish?
10. How may fish be affected by the installation of dams or power plants, or by the removal of natural barriers?

Fish ladders help the salmon in their up-stream fight to their spawning-grounds.

Newfoundland Tourist Development Board

PART III: WATER

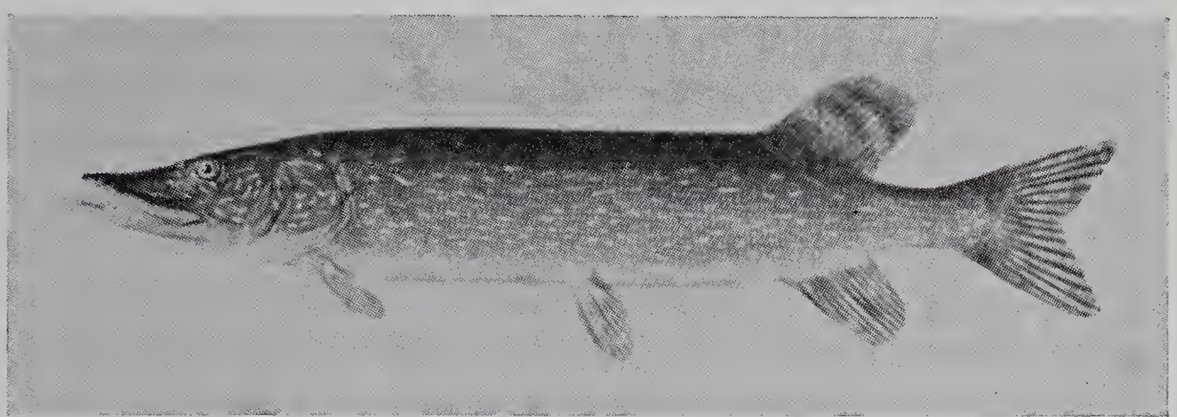
17 Joe's Last Day

Joe, the Northern Pike, lived in the Vermilion River. He was not a very large pike, but he had a sinister expression, and wore an ugly scar on his left side where he had been grazed by a spear. His favourite spot was a place where the river became wide and sluggish and the weed beds were rank and shady. Here it was his custom to lurk in the sun-dappled shadows, while he searched the weedy labyrinths with callous, unblinking eyes.

Today he was unusually hungry and morose, for, in spite of his almost perfect camouflage, the small fish seemed to sense his presence and kept a long way from his hard mouth and vicious teeth. Now and then he darted at a young pickerel or silvery minnow, but each time his intended prey eluded him, and he returned to his ambush with rancour in his heart and nothing in his stomach.

Suddenly he was startled by a most extraordinary apparition. A gorgeous, sprightly minnow came glancing through the

water. His gleaming sides were yellow and green, and a dazzling light flashed from his head. He moved with an erratic twitching motion, and seemed possessed of boundless energy as he rushed at Joe and then continued on his way, disdainfully ignoring him. First curiosity, then anger, led Joe to follow the brilliant minnow. Suddenly he darted ahead, blind with rage, and his jaws snapped viciously on his gaudy victim. Imagine his disillusionment when steel barbs sank into his jaws, and he was jerked through the water by a rapidly short-



The Great Northern Pike ranges from Labrador clear across the country to Alaska, and is found in almost every conceivable type of water.

ening line. In vain he tried to dive into the weeds. The pull of the troll was irresistible and he could turn neither to right nor to left. Soon he ceased resisting and swam in the direction of the tugging line, shaking his head in a frenzy as the line slackened. Luckily for Joe the barbs were not deeply imbedded, and before he realized it he was free.

His adventure had brought him to a place in the river where a cool stream entered, and as he rested on the bottom he became aware of a small speckled trout feeding on tiny organisms brought down by the current. This time Joe made no mistake, and the little trout disappeared head-first down his capacious gullet.

Feeling rested and refreshed, Joe swam lazily up the river, not bothering to chase the scattering minnows. Presently he approached a school of pickerel fry and was surprised that

they seemed scarcely aware of their danger. Hardly exerting himself, he seized and swallowed several of the nearest. Instead of darting away, more fry kept drifting towards him in an apparently endless stream. For several minutes Joe swam leisurely in the direction from which this manna came. Then abruptly he stopped, tail flexed and pectoral fins vibrating. A sound of splashing had reached him, and the vibration of human voices. Peering ahead through a haze of turbid water he saw a cylindrical object around which moved two pairs of black rubber boots.

"Temperature's all right now, Ed," said a voice. "Tip 'er over." Immediately the can was turned on its side, and from its mouth poured a swarm of pickerel fry. Joe now discovered that he was not alone. Many of his kinsmen were lurking in the dark, weedy patches, all heads pointing towards the mouth of the green cornucopia. How many fry were eaten, and how many escaped, I cannot say, but Joe certainly did justice to the occasion, for he was an unusually plump pike when finally he left the feast and started back towards his favourite patch of weeds.

He felt drowsy as he drifted down with the current, and probably that is why he did not notice the net till he poked his long snout between the knotted cords. At first he thought it was a tangle of thin weed stems and tried to force his way through, but he soon found that this was impossible. When he tried to back out, the cords slipped under his gill-covers and held him securely. Then he became desperate, lashing and thrashing in a blind panic. The violent action convulsed his distended stomach, and he disgorged all that he had eaten. This proved fortunate, for it was now possible for him to squeeze slowly through the tight mesh. Still it was a long struggle, and when he found himself free once more he was utterly exhausted, his stomach was empty, his body was covered with net scars, and his mouth still ached where the hooks had torn it.

He was so weak and dazed that he drifted past his weedy

home and down to a part of the river that he had always avoided. Presently the river flowed past some large buildings, and suddenly the water became vile and distasteful. Joe's gill-covers widened and he breathed faster and faster, but the water seemed to have lost its life-giving power. Soon he lost consciousness altogether and floated belly-up on the polluted current. For several miles he was carried in this fashion, until the poisons became diluted and he was able to right himself again. Still he was helpless in the grip of the current, which now flowed with the force of a whirlpool. A few seconds later he was flattened against an iron grate while from far below came the powerful hum of giant dynamos. Joe struggled desperately against the relentless suction. From time to time he got a short distance from the bars, only to be pulled back again. After struggling in this way for more than an hour he found himself at the end of the iron grill. With a great effort he managed to get away at last from the terrific suction, and into the relatively quiet water nearer shore. More dead than alive, he worked his way into a shallow backwater, and here befell his last adventure. The water above him burst open, and in an instant he was gripped by powerful talons and hoisted into the air.

Two fishermen coming down the river in their motor-boat saw the plunge of the great osprey, and watched him fly homeward with his prize.

"That explains why we can't catch fish in this river any more," said the man who was reeling in a troll; "there should be a bounty on those birds instead of protecting them."

"Oh, I don't know," said his companion, who was stringing together half a dozen undersized bass. "There may be other reasons as well."

QUESTIONS

1. Describe the appearance and habits of the Northern Pike.
2. Would it be advisable to destroy all pike because they are known to prey on game fish?
3. Is it likely that many hatchery-bred fish survive after they are liberated in natural waters? Make a list of the hazards they might encounter.
4. What is the purpose of game laws? How many examples of laws being broken can you find in this story?
5. Was the man in the boat right in blaming the osprey for the poor fishing? What are some of the "other reasons"?

Newfoundland Tourist Development Board

PART III: WATER

18 The Salmon

To many people the salmon is the ideal fish. It is sporting to catch, delicious to eat, and its life history is one of the most fascinating in the annals of nature. We know that it was highly honoured even in the days of the cave man, for there are pictures of salmon carved on reindeer bone dating back to about 12,000 B.C. The Romans first became aware of the salmon when they conquered Gaul and Britain. They gave it the name Salmo from the word *salire,* meaning "to leap". This is the same kind of salmon that is found on our Atlantic coast. The various types of salmon found on the Pacific coast do not belong to the genus Salmo but their habits and life history are similar.

At one time the Atlantic salmon came as far inland as Lake Ontario and spawned in great numbers in rivers such as the Don, the Humber, and the Credit in the neighbourhood of Toronto. They were so numerous, in fact, that hired men refused to work on the farms unless it was clearly understood

Salmon have brought international fame to a number of rivers; such a one is the Humber, in Newfoundland.

that they would not have to eat salmon more than two or three times a week! After 1870 the salmon declined very rapidly and soon disappeared from the region completely. Dams and mills had obstructed their migration, deforestation had made the streams warm and muddy, and the water was becoming polluted by wastes from homes and factories. The Atlantic salmon is now secure only in the Atlantic provinces, where it is greatly prized both for commerce and for sport.

When the salmon return from the sea to the rivers they are in the peak of condition, but once in fresh water they apparently cease feeding as they work their way up to the spawning-streams. Why they take the artificial flies of the fishermen no one knows, but the fact that they do results in one of the greatest thrills that sports fishing can provide. Fishermen from all over the world come to the Atlantic provinces each year to match their wits, with light rods, fine leaders, and filmy flies, against the strength and cunning of these noble fish. In British Columbia the coho and spring* salmon respond to flies in the same way as the Atlantic salmon and provide exciting sport for anglers.

However, the salmon of the west coast are essentially commercial fish, the fisheries having an annual value of over $60 million and providing employment for at least 20,000 people. Most of the salmon catch is canned, the annual pack being about 1.5 million cases. In these cans and cases is concentrated the food wealth of the ocean that the salmon have built into their bodies during their years of foraging at sea. All aquatic life, no less than life on land, depends on vegetation. In lakes and oceans the vegetation is mostly in the form of microscopic floating plants which exist in enormous numbers and which usually go unnoticed unless they become so thick that they darken the water or change its colour. This suspended vegetation (including the microscopic animals asso-

* Also called chinook.

ciated with it) is called *plankton,* and it is the source of food for all the creatures of the ocean. Those that do not eat it directly feed upon the shrimps and smaller fish that subsist on plankton, just as rabbits feed on grass and are in turn eaten by foxes. The great value of the salmon is that it makes all the valuable nutrients of the plankton available to man in a highly concentrated and palatable form.

The most valuable of the western salmon, the sockeye, spawn in great numbers in the upper reaches of the Fraser River. They usually arrive at the river mouth when they are four years old, and those that are not taken by the commercial fishermen continue up-river in search of the spawning-beds where they themselves were born. As they work their way up-stream they are sometimes so crowded that the water seems to be a solid mass of fish, and it is quite obvious that there could not be enough food in the water to feed even a small percentage of them. However, nature has prepared them for this during their time at sea and their bodies are rich in fats and other nutrients, which now supply them with the energy they need. It is well that they have this supply of stored energy, for without it they could never fight their way for hundreds of miles up-stream, leaping waterfalls and struggling through turbulent rapids.

Hell's Gate canyon is one of the first great challenges that the migrating salmon meet as they work their way up the Fraser River. At one time a rock slide almost completely blocked the upward passage of the spawners, and although the worst of the slides were removed the salmon fisheries declined for a considerable time. Special fishways or fish ladders were installed at the canyon in 1945 and 1946, and since that time the salmon have passed freely. Other improvements were brought about by making passages through the rapids and removing man-made obstacles in some of the important tributaries. A great improvement in the fishery has resulted from these changes, an improvement that could never have been

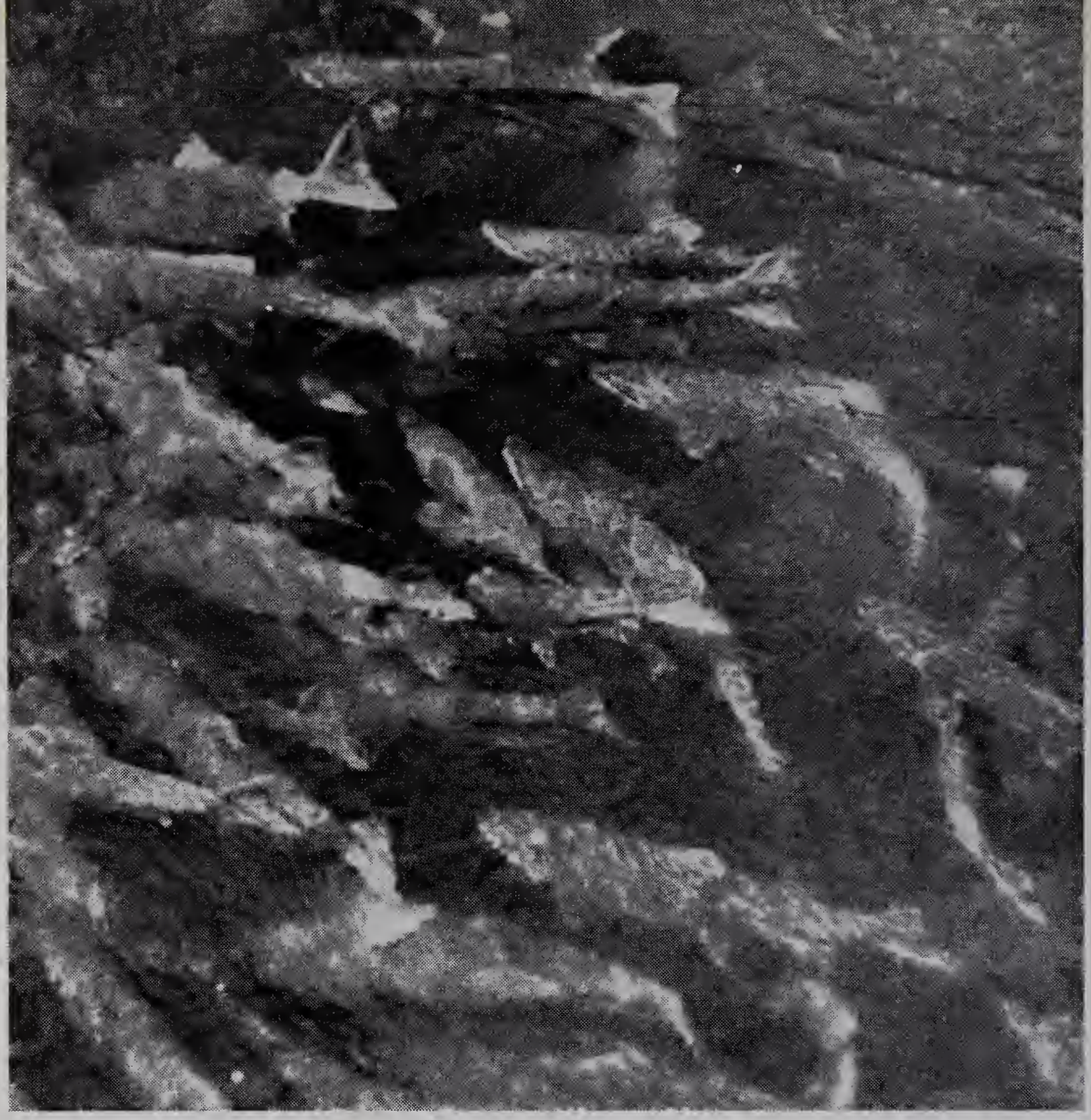
achieved by relying on hatcheries to take the place of natural spawning. Each of the important tributaries drains a system of lakes, such as the Shuswap, the Chilco, the Quesnel, and the Stuart Lake systems. The sockeye salmon prefer to spawn in flowing water just above or below a lake. When the young fish hatch they move into the lake and live there for at least a year before starting down-stream for the sea. Each "run" of sockeye salmon instinctively finds its way to its own lake system, the one from which it came, thus making the Chilco run, the Stuart Lake run, the Quesnel run and so on.

Apparently nature has decreed that the salmon should make this long journey so that the young may be born in a protected place far from the multitude of enemies that swarm in the sea. How they are guided on their migration is one of the great mysteries of nature. First they must find their way through the trackless ocean to the right river mouth; then they must ascend the river with all its bewildering turns and twists, pass all the tributaries but the right one, and finally arrive at the place where they themselves were hatched. Perhaps they are guided by the temperature or the chemical condition of the water or the velocity of the current, but no matter what explanation we attempt it still remains an unsolved mystery.

When they finally arrive at the spawning-beds they pair off and seek out a suitable site for a nest. The bottom should consist of coarse gravel or pebbles and the current should be swift enough to prevent sand or silt from settling on the eggs and smothering them. When she is satisfied that all the conditions are right, the female turns sidewards and uses her tail to scoop out a hollow space and wash away any small particles from among the stones. While this is going on the male stands guard and drives away intruders. When the nest or *redd* is finished both fish settle to the bottom, the female releases the eggs into the spaces among the pebbles and at the same instant the male extrudes a white liquid called milt which fertilizes the eggs. The female then moves forward and loosens

Hell's Gate in the Fraser River canyon is aptly named, as this photograph illustrates.

British Columbia Government



British Columbia Government

Sockeye salmon spawn in many British Columbia rivers.

some of the stones just ahead so that the current rolls them into the nest. This provides additional protection for the eggs which are now several inches below the bottom in well-washed spaces among the stones. Not all the eggs are deposited at one time or in one place. A number of nests will be made and the spawning may continue for several days.

All species of Pacific salmon die within a few days of spawning, but a considerable number of Atlantic salmon survive and may return to spawn several times during their lifetime. The eggs hatch early in the spring and the fry or *alevins* as they are called, live for some time on the food contained in the yolk-sacs attached to their bodies. When the yolk is absorbed the tiny fish begin feeding on plankton. At this stage they are called *parr*. When they are a little larger,

about the fingerling stage, they are called *smolts*. These young salmon, or as many of them as survive the hazards of life in fresh water, work their way down to the ocean. If they survive to grow to maturity in the ocean they return once more to the river of their birth to continue the cycle of life. There is not much we can do about the hazards of the ocean, but we can do a great deal to prevent many of the disasters that overtake the salmon during the freshwater part of their lives.

Forest fires or excessive lumbering operations may destroy the water-holding capacity of the land, with the result that the water-level may drop and expose the spawning-beds. Lack of forest cover also permits rapid run-off that may result in the eggs being choked with sediment. In many instances the building of dams to produce electric power has had serious effects on the salmon runs. If a dam is not too high and is equipped with an efficient fish ladder, the salmon can work their way past it and continue their upward migration. But each dam takes its toll in energy and time, and if there are too many obstacles the fish may die before reaching the spawning-grounds. Dams are also a serious menace to young fish on their downward migration. Very high dams such as the Grand Coulee Dam on the Columbia River are quite impassable, and where such obstructions exist, the yield of the river is sure to decline very seriously. Irrigation ditches and canals can be a great hazard to young salmon. If the ditches are unscreened, thousands of small fish may wander off into them and become stranded in the fields. Drawing off excessive amounts of irrigation water may lower the water-level in the streams, killing many more. Pollution, of course, is another hazard against which we must always be on guard. As well as industrial wastes and domestic sewage there is the possibility of chemical sprays used for insects or weeds being washed into the rivers.

The life history of the salmon illustrates some of the complex problems we must try to solve if we are to manage our wild-life resources successfully. Some of these problems are concerned with nature and our need to unravel the mysteries

that still elude us, but many of them are human problems arising from carelessness or greed, or the clash of interests when the development of one resource conflicts with the development of other resources.

QUESTIONS

1. What is the Latin name of the Atlantic salmon? Why was it so called?
2. Why are salmon no longer found in Ontario?
3. How many different kinds of salmon are found on the Pacific coast? What are their names?
4. What is plankton? Why is it important?
5. Why is the sockeye the most valuable of the Pacific salmon?
6. Write a brief account of the life history of the sockeye salmon of the Fraser River. On a map of British Columbia locate the tributaries frequented by the various "runs".
7. Why do the sockeye salmon spawn (a) in flowing water, (b) near a lake?
8. What are the names given to the young salmon at various stages after they hatch?
9. What are the main hazards the salmon encounter during their life in fresh water?
10. What do you think should be done to reduce or eliminate these hazards?
11. What is meant by "conflict of resource uses"? Give some examples.
12. Give a number of ways of producing electricity without the use of water power.

PART IV: THE FOREST

19 The Living Forest

Canada's forests cover about 1,700,000 square miles or approximately half the total land area of the country. They are among the finest and most extensive forests in the world and contain a wide variety of trees of great economic value.

A forest, however, is more than a collection of trees. It is a great and complex association of living things – bacteria and fungi, mosses and lichens, ferns, wild-flowers, insects, birds, reptiles and mammals – all of them struggling for existence, competing for space and food, reproducing, and dying in accordance with the laws of nature. Even the trees have to compete with one another for existence, and in spite of their apparent peace and serenity they are involved in a fierce but silent struggle for space and light.

The forest makes its own climate – cool, shady and moist. It reduces the violence of the wind and the fierce heat of the sun, and in many ways maintains a favourable habitat for all the forms of life that make up the *forest community*.

Hugh Halliday – Wheeler Newspaper Syndicate

The white-footed mouse, even when frightened, refuses to desert her family.

The various forms of life are not independent but influence one another and react on one another in a variety of ways. Squirrels gather seeds and nuts for food, and in so doing they leave many seeds in the ground which germinate far from the parent tree. Insects attack nearly every kind of plant and animal, and the insects in turn are eaten by birds, shrews, and spiders, and even by certain plants such as the pitcher plant and the sundew. Warblers and vireos consume great numbers of insects, and with their allies the nuthatches, tree-creepers, and woodpeckers they wage a never-ending war on these tiny but deadly enemies of the forest.

Within the forest are vast numbers of small furtive creatures that we rarely see because their lives depend upon their ability to keep hidden. The deer mouse, or white-footed mouse, is one of the prettiest of the small forest dwellers, with his large boot-button eyes and his dainty paws like tiny human hands. He and his cousins, the meadow mice, are for the most part vegetarians, feeding on leaves, grass, seeds and bark. Rabbits

The yellow warbler is one of the forest animals whose survival depends partly on protective colouration.

Hugh Halliday – Wheeler Newspaper Syndicate

also are vegetarians and together with the mice they provide food for the larger flesh-eaters – the fox, the weasel, the owl, and the hawk. Many similar *food chains* exist within the forest: insects feeding on vegetation may be snatched up by a frog, which is then swallowed by a snake, which in turn is devoured by a hawk. Another well-known food chain has only three links: tree foliage, deer, and wolf. This apparently cruel game of hunting and being hunted is nature's way of controlling the various forces that, if unchecked, would destroy the forest and all the life it sustains.

All living things have the ability to increase their numbers by reproduction. In some cases this ability is so great that in the absence of natural enemies it may give rise to almost unbelievable numbers. Insects, as you know, reproduce at a tremendous rate, and there have been many instances where species such as the tent caterpillar and the spruce budworm have infested and destroyed great areas of forest. Mice also reproduce very rapidly and it has been estimated that a single

The spruce budworm is one of the links of a forest food chain. When the balance is upset in favour of these insects great damage to the forest results.

Wheeler Newspaper Syndicate

pair of meadow mice, under ideal conditions, could have 1,000,000 descendants by the end of a year. Even a pair of deer could have as many as 50 descendants in a ten-year period. When a particular species becomes too numerous the competition for food intensifies and starvation often results. The role of the predator is therefore very important and not unnecessarily cruel. Not only do predators keep the numbers down, they also improve the species by weeding out the unfit and allowing only the strongest to survive and reproduce. If man destroys too many predators he upsets the process of *natural selection* and exposes the herbivorous animals to over-population and eventual starvation. Under natural conditions the continual interaction between all the various forms of life keeps the population adjusted to the number of each species that the forest can safely support.

In such a competitive environment no waste can be tolerated and everything is made to serve a useful purpose. A jagged stump where a tree has been splintered by lightning provides an excellent home for a family of woodpeckers. Insects soon penetrate the wood and those that escape the woodpecker help to bring about the decay of the stump. When the woodpeckers leave, other birds find a nesting-place or a squirrel finds a ready-made home. The fallen tree with its tangle of branches provides cover for the partridge and a stage where the male bird can strut and drum. Insects penetrate the bark, and as the log decays it is mined by colonies of ants. Then a bear tears it to pieces to feed on the ants and the clean-up job is completed by beetles and other tiny scavengers.

In the forest, as elsewhere, life depends on the process of photosynthesis. The trees take minerals and water from the soil, and carbon dioxide from the air, and from these elementary substances they build their own bodies and provide food for the life that takes shelter beneath their branches. In this way the forest community lives and grows, utilizing the energy of the sun which is trapped by the green leaves and handed on to the other living things. The herbivores obtain this stored

energy directly from the leaves, and the carnivores obtain it from the bodies of the herbivores. In the end both the hunters and the hunted die, and their bodies are decomposed by fungi and bacteria to add fertility to the forest soil. The same fate awaits the trees themselves, and so a thick carpet of humus is gradually built up consisting of decayed leaves and the decomposed bodies of dead plants and animals. In the humus the essential mineral substances, including nitrogen compounds, are reduced to a soluble form for re-entry into the stream of life. The trees absorb these elements through their roots, and the life of the forest goes on in an endless cycle.

It is not hard to realize that the animals of the forest draw their life from the trees, but what we often fail to realize is that the condition of a lake and the quantity of life it can support depend to a great extent upon the surrounding forest.

Aquatic life, like all other life, depends directly or indirectly on vegetation. Some aquatic vegetation is rooted in shallow areas and some is the free-floating type we call plankton. In either case the plants depend upon essential minerals washed into the lake from the surrounding land. A lake must receive a constant supply of nitrogenous matter, the best source of which is the humus from the forest floor. If the drainage area of a lake or pond is treeless or if the forest is thinned out too much, the supply of nitrogen and other elements in the lake may be seriously reduced. As a result the vegetation becomes scanty and there is a marked decrease in the quantity of fish and other aquatic life that the lake can sustain.

Indiscriminate logging and forest fires can also do great damage to streams by removing the shade and thereby changing the temperature of the water so that fish cannot live. Destruction of forest cover also causes quick run-off, resulting in erosion and silting and the smothering of fish-food and eggs.

From this discussion it might appear that all other forms of life in the forest depend upon the trees. However, it is not so much a matter of dependence as *interdependence,* for we must remember that the trees depend upon the birds to protect

them from the ravages of insects, and if it were not for wolves and foxes not a single seedling would survive the nibbling of deer, mice, and rabbits. Some forms of life in the forest community may seem more important than others and some may seem definitely harmful, but the degree of value or harm depends on how well the balance is maintained between the various conflicting forces.

Even in the natural state the balance is not perfect. Sometimes it sways a little too far in one direction and sometimes a little too far in the other, but if left to herself nature will make the necessary adjustments and restore things to normal before they get too far out of control. It is when man interferes and destroys the balance by excessive cutting, by forest fires, or by killing too many animals that very serious and sometimes irreparable damage is done.

QUESTIONS

1. What proportion of the land area of Canada is covered by forest?
2. What is meant by "the forest community"?
3. If mice are so abundant in the woods, why are they rarely seen?
4. What is a "food chain"? Give some examples other than those mentioned in this chapter.
5. What are predators? What is meant by the term "natural selection"?
6. Should all hawks, owls, and wolves be destroyed because they are predators? Give reasons for your answer.
7. What is meant by "the nitrogen cycle"? Describe how this cycle operates in the forest.
8. How could the destruction of the surrounding forest affect the life in a lake or pond?
9. How does the removal of forest cover affect a stream or river?
10. What is meant by "interdependence"? Is it true that a forest might owe its existence to the presence of wolves, foxes and other predators? Explain.
11. What are some of the "conflicting forces" that operate within the forest? How does nature maintain a balance between these forces?

PART IV: THE FOREST

20 Dwellers Among the Leaves*

. . . People having the dim, distorted ideas that are held by so many concerning animals can gain very little insight into their true natures. Each animal has his separate personality, easily distinguishable to one who knows him. Among the more highly intelligent species no two individuals seem to be alike, each having an individuality all his own. Their ways are often so extraordinarily human, and this is especially true of the rodents. They seem at times so rational, their movements are often so much to the purpose, and their actions, and their manner of expressing their emotions sometimes so childlike – the little side glances, the quaint and aimless gestures, their petulance if unduly annoyed, their artlessness and lack of guile, their distress when in some small trouble, their so evident affection for each other – I have never ceased to regret the thousands of them I destroyed in earlier days. Even then I never enjoyed killing them, preferring to find them dead, refusing to visualize the hopeless struggle, the agony, the long

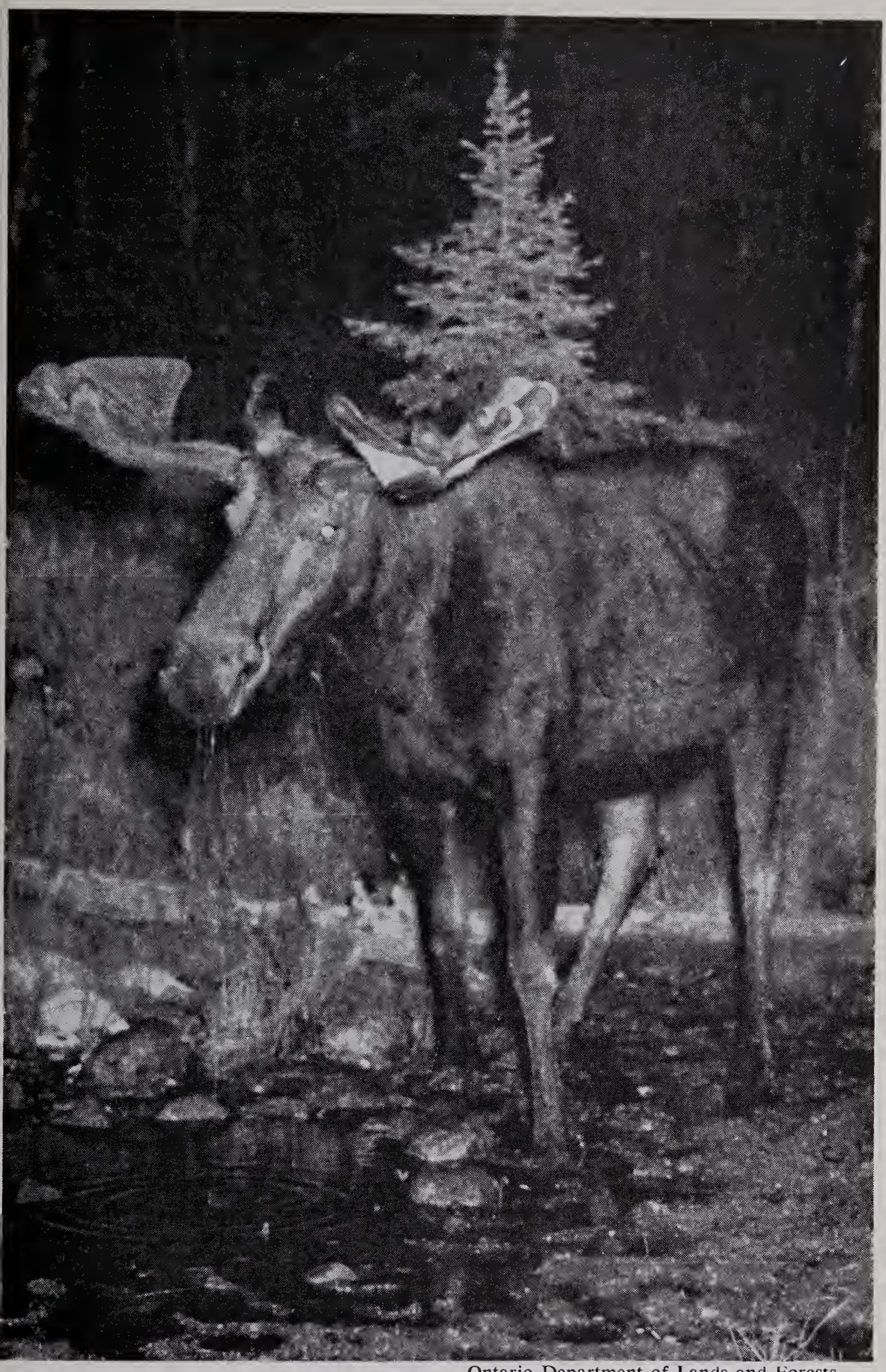
* Reprinted from *Tales of an Empty Cabin* by Grey Owl, published by The Macmillan Company of Canada Limited.

hours of awful misery. And today I feel that however great the inconvenience they may put me to, I can never pay the half of what I owe them. Only those who have suffered similar tortures can have any conception of what trapping by present methods really means to the animal population of the woods. . . .

Owing greatly to the ignorance, thoughtlessness or intolerance of many who come in contact with them, some really harmless creatures have been saddled with a reputation for evil that they do not deserve, and are penalized accordingly. All that most of them need is a little sympathy, and most of all to be let alone to mind their own business. Though I must admit that sometimes this "business" is a little ill judged, as in the case of the skunk who took refuge in my store-tent, sleeping there regularly, and who repaid my hospitality by having, in amongst my provisions, a family of kittens, or pups, or skunklings – or is it skunklets? This was no doubt an oversight and no harm was intended, I am sure, and everything turned out all right, and no one was a bit the worse off for it. The skunk is really a natural gentleman (or lady), but unfortunately is not a mind reader, so he cannot always gauge with accuracy your intentions towards him when you bump into him suddenly in the dark. Usually they (your intentions) are hostile, and he acts accordingly, but he is slow to anger and of monumental patience; and his feelings must be badly outraged before he will turn his battery on you. Meeting him in the moonlight is sometimes startling, for then his long, white horizontal markings and white cap are accentuated and, the rest of his coat being black, are all that can be seen; so that as he turns quickly this way and that with supple movements, he looks at first like some darting white snake with a venomous head. But he is an inoffensive, happy-go-lucky beast with a fixed idea that human beings like to find him in tents, camps and outhouses, and under the flooring of summer cottages. Even so, finding a skunk in a storehouse is not nearly as inconvenient as discovering a moose in a canoe; and I once

had this interesting experience, although I hasten to add that I was *not* in the canoe at the time. It was on shore, drawn up, awaiting my early departure that day for Waskesieu, thirty miles away and all by water. As I was making my preparations I heard, outside, a sort of light crackling, crushing sound, and looking through the window saw my friend the moose (previously mentioned) walking slowly, steadily, and very thoroughly, through and along my canoe. I rushed out of the cabin at him, shouting, and this seemed to remind him of something, so he extricated his feet from the various holes, where they must have felt most uncomfortable, and stood aside, surveying the wreckage with an air of rather thoughtful detachment. Now this was nothing but rank carelessness on his part, and I remember having a distinct feeling of annoyance about it. Granted that he was a youngish moose, and perhaps did not know much, the fact still remains that a canoe is a very handy thing to have when you have a thirty mile trip to make, entirely by water. A moose is rather a terrific object to have around, being about the size of an overgrown horse, and it is as well, if your visiting list includes one, not to have any breakables around where he can walk on them. So in all fairness I must take some of the blame for this affair, for not having carried the canoe up a tree in the first place and secured it there. So, forgiving the moose, I placed the injured craft up on a rack, intending to mend it, where, in this unusual position it became an object of intense interest to the beavers. One night these enterprising animals, with the high intelligence for which they are celebrated, carefully felled a large tree across the long-suffering canoe, reducing it to the very best of matchwood. . . .

Every one of these so-busy dwellers in the Wild Lands presents intriguing possibilities, and has a life history well worth a little patience in the studying. Even those that live in the water, or on it, and are therefore more difficult to cultivate, have an interest that is easily discovered by a little investigation; all the way from the water beetles, that leave their



Ontario Department of Lands and Forests

This fine specimen of a bull moose was photographed at a salt lick near Lake Superior.

natural element to climb on rocks to sun themselves, to the proud, white-throated loons, greatest and most accomplished of all the diving birds, who run races round and round the lake with the most inordinate splashing and other uproar, and play a kind of water leap-frog, driving the beavers to distraction with their weird, half-human laughter. These royal birds, however, cannot walk, but are strong fliers and real artists in the water. When they take their young ones out for exercise – there are usually only one or two – the wee, jet black chicks sit upon their mother's back, getting a free ride while they look around in the most complacent manner at the scenery. . . .

Every one of these creatures has his proper function, and each, however apparently useless, serves well the purpose for which he was created. Even diminutive birds, negligible-appearing denizens of these wild solitudes, have their own appointed place to fill. Seemingly quite superfluous in the vastness of the mighty scheme about them, yet as they hop happily in little groups among the fallen leaves, seeking the wherewithal to maintain their tiny lives, competent, wise, and bright-eyed and very much at home, who that watches them will question their right to be, or doubt but what they also do their part?

Animals quickly know a sanctuary when they find one. How I cannot tell; something in the atmosphere of the place perhaps, or some kind of telepathic divination all wild creatures seem to be possessed of, may account for this. . . . While some need time to figure out the situation, others will respond almost immediately to my advances, depending upon the disposition or intelligence of the individual. . . . Seldom am I without one or another of my dependents, even though they are not always visible. The crash of a new-fallen tree, or a shrill outcry of adolescent beaver voices from the lake, may disturb the sleeping echoes. The door is thrown open and a load of mud and sticks comes in, borne in furry arms and intended as materials for the earthen lodge that stands inside my cabin; then a light pitter-patter across the floor, as a muskrat calls in for his

nightly apple; comes the rattle of antlers among the willows – these sounds, familiar to me as are street noises to a town-dweller, tell me that I am not, after all, alone.

This region, like any other Wilderness, has its population of predatory animals, and I must be forever on the watch to safeguard my fellow-citizens from harm. Wolves, coyotes, bears, owls and mink and weasels are all potential and very active enemies; nocturnal creatures who can operate in the daytime with the same facility that they do at night, furtive, sly, and ever-hungry, could slip silently in to deal out death in a moment of time and be quickly gone. . . . So that my life has become something like that of a scout of ancient days of forest warfare, and even if asleep, any unusual sound from the surrounding woods, or unwanted commotion in the beaver's house, or even the abrupt cessation of some familiar noise, brings instant wakefulness. Danger lies hidden in the lurking shadows, waiting for the day when the high-tuned senses of my retainers, or my less perfect ones shall be at fault; yet not without due warning can it ever strike. The woodchuck who haunts my wood-pile, and who should be sleeping, whistles sharply, for no apparent reason, into the night; comes the discordant warning cry of a whiskey-jack, the sudden alarmed scurry and subsequent shrill defiance from a safe retreat of a squirrel – then, softly, the muffled hoot of an owl who, in his downy sanctimonious robe of white, like a robber-priest of some false religion fattening on the community about him, broods rapaciously above them like an evil spirit – or, a breath of sound, a flicker that is quick as a flame, the sinuous, reptilian slither of a weasel, small but deadly, swift, lithe, and ruthless – gangster and cut-throat par excellence of all the Wilderness.

Later, perhaps, as I listen, the precise, dainty stepping of a deer ceases for a moment, to break into a series of startling leaps; a nearby moose, visible to me by the light of the moon, pauses suddenly in his browsing to catch some seemingly non-existent sound, or to sniff a warning from a vagrant current of

air; from the lake the cry of a loon, pitched at an uncommon note, off-key a little, weird and alarming, strikes a jarring note of discord. And then, most portentous of all, shattering the night like a rifle shot, there crashes out the appalling detonation of a beaver's tail-slap on the water – and then falls silence, ominous and nerve-racking, surcharged with menace, as every living creature within earshot stops motionless in its tracks, crouched, or in an attitude of suddenly arrested motion, its senses keyed to an excruciating pitch of sensitivity, waiting for someone to make the first move. And then I see shifting, wavering like a disembodied spirit through the shadows, unsubstantial as a phantom, the ghoul of all the forest lands – a wolf! . . .

And all these things that may be seen and heard, and other things that may not be even heard, but are a kind of feeling, advise me more positively than the spoken word, are as clear to me as lines of print, telling me how it fares with my Little People, and the big ones too, reminding me, sleeping and waking, of my responsibilities towards all things both great and small that within, without, and all about, dwell here under my protection.

PART IV: THE FOREST

21 The Economic Value of Forest and Woodlot

"The tree is one of the great gifts of a Creator ever-mindful of the welfare of mankind.

"It conserves the soil, protects it, and adds to its fertility. It tempers the cold of winter, the heat of summer. It lessens the violence of the gale. It helps man to build his shelters, to furnish them, and to give them warmth. It provides clothing for his body, food for his stomach, medicines to cure his ills and ease his pain.

"From the tree come pigments that please the eye and win the artist a livelihood. The sculptor carves in wood as in stone. There could be no symphony orchestra without the tree. Through paper, to which men commit thought, knowledge is shared and the mind enriched.

"Motor-cars move on wheels sheathed with a product of the tree. The most popular of all ice creams, vanilla, may be flavoured with a by-product of the tree.

"The tree is one of the Magi of man's universe. Its gifts are many, its favours manifold. It has always been so, and if man,

its trustee, is faithful to his obligations, it will continue to be so.

"Search history where you will, from the Trojan Horse of legend to the modern household, from the Garden of Eden to the super-market, always you will find the tree serving man by bettering his life and refreshing his spirit.

"It was a wooden ship in which Ferdinand Magellan's sailors first circumnavigated the world in 1519-1522, thus proving it to be round. Canada was explored and expanded by men in canoes fashioned from birch bark stretched taut over cedar ribs. The design for the lighthouses that dot the sea coasts of many lands was borrowed originally from the sturdy oak with its broad pedestal and tapering stem. Elements from the tree are in the projectiles man has sprung into space to whirl in orbit with the stars. And from the tree today comes the currency of civilization: paper and paperboard that carry throughout the world the fruits of men's hands and the fruits of men's minds.

"Where the tree dwells, man has a chance to live a bountiful, happy life. Where there are no trees, life is as barren as the landscape.

"Give thanks for the tree. And in giving thanks, grant it the mercy of protection."

[Reprinted from *The Incredible Tree* by G. Herbert Lash, by permission of The Canadian Pulp and Paper Association.]

The first explorers who reached our shores were searching for a passage to China and India; so they saw in the forests of Canada little more than an obstacle blocking their way to the riches that lay beyond. Here were no great cities and glittering palaces, but only the dark and silent forest stretching endlessly toward the setting sun. Little did these sturdy mariners realize that the forest, to them so forbidding, would become the source of far greater wealth than the spices and gold of the East.

They were not alone in failing to realize the value of the forest, for it was not until 100 years after Cartier that the

British Columbia sawmills, using the large logs of the coastal forests, run at high speeds and turn out a wide range of specialized grades and sizes of lumber.

Donovan Clemson, Armstrong, B.C.

French government began to make use of the Canadian forests to obtain wood for shipbuilding. This practice was later continued by the British, and many of the ships that helped to defeat Napoleon were made of choice oak and pine from the forests of eastern Canada.

Gradually the demand for Canadian timber increased and before long the valleys of the St. Lawrence and Ottawa and their tributaries resounded with the axes of the shantymen cutting and squaring the great timbers that were rafted down to tidewater for export. As civilization spread westward the forests played an essential part by providing logs for "corduroy" roads, ties for railway tracks, timber for bridges, and fuel for the "iron horse". Without such means of transportation it is doubtful if Canada would ever have become one nation "united from sea to sea".

Primitive sawmills operated by water power soon made their appearance in the various settlements where they supplied lumber for the settlers' requirements. From these small beginnings the lumber industry developed rapidly to keep pace with the growth of roads and railways and the settlement of the country westward and northward. In the latter part of the nineteenth century sawmills became more numerous and sawn lumber was in great demand both for local building and for export. The great trees of British Columbia provided vast quantities of excellent lumber, much of which was exported to the rapidly growing United States. Later, with the opening of the Panama Canal, trade with Europe increased and the lumber industry expanded accordingly. During the present century the lumber industry has continued to play a leading role in the economic growth of the country. It stands high among other manufacturing industries in total employment, in the value of its product, and in wages paid.

Canadian sawmills vary greatly in output as well as type of product. Some of the large mills of British Columbia are capable of cutting half a million board feet in a single shift, while many of our smaller mills can cut only a few thousand

The lumber is stacked for drying before being shipped to its destinations in various parts of Canada and other countries around the world.

board feet a day. Spruce, Douglas fir, hemlock, cedar, white pine, jack pine, balsam fir, yellow birch, and maple are the chief woods used for sawn lumber.

Lumber enters into the construction of buildings of all kinds, ships, railway cars, trucks, boxes and crates, furniture, and a variety of products essential to modern living. As well as lumber for construction purposes, Canada's thousands of sawmills are turning out great quantities of railway ties, shingles, mine timbers, laths, and many other products. Some mills extend their output to include stock of special dimensions that can be manufactured rapidly into such items as spools, table legs, and handles for tools.

After supplying all our own needs we are able to export over 60% of the output of our sawmills. For this we obtain upwards of 300 million dollars annually, depending on market conditions.

In spite of the great importance of lumber, its value is small when compared to the value of pulp and paper. During the last

This aerial view shows a pulp-wood storage-area and a portion of the mill in the background.

Dominion Bureau of Statistics

MALAK, Ottawa

These rolls of paper are labelled before being shipped to other countries.

century the pulp and paper industry has grown from small beginnings to become the nation's greatest manufacturing producer and exporter.

Until the middle of the nineteenth century paper was made for the most part from cotton and linen rags and was consequently both scarce and expensive. Only well-to-do people could afford books; newspapers and magazines did not circulate widely, and school children wrote their lessons on slates. When a chemical process was invented for making pulp and paper from wood the reading habits of the world were revolutionized, giving great impetus to the economic development of Canada. The first chemical plant for producing wood-pulp in Canada was built in 1869 near Sherbrooke, Quebec. In this plant caustic soda was used to dissolve out the non-cellulose part of the wood. As new mills sprang up in answer to the

demand for pulp, the process was rapidly improved so that the quality of the product improved and the cost of production went down. The development of this process made it possible to utilize vast areas of Canadian woodlands formerly considered useless because the trees were too small or otherwise unsuitable for lumber.

Half the world's newspapers are now printed on Canadian newsprint, and great quantities of pulp go into the manufacture of writing-paper, wrapping-paper, paper packages, and tissues of all kinds. Because of the world-wide demand for these products, the pulp and paper industry has grown to exceed all other industries in the value of its product. It also ranks first in the value of its exports, in total wages paid, and in the amount of money invested in it. The total value of its production is about 1.5 billion dollars a year, exports alone totalling over a billion dollars.

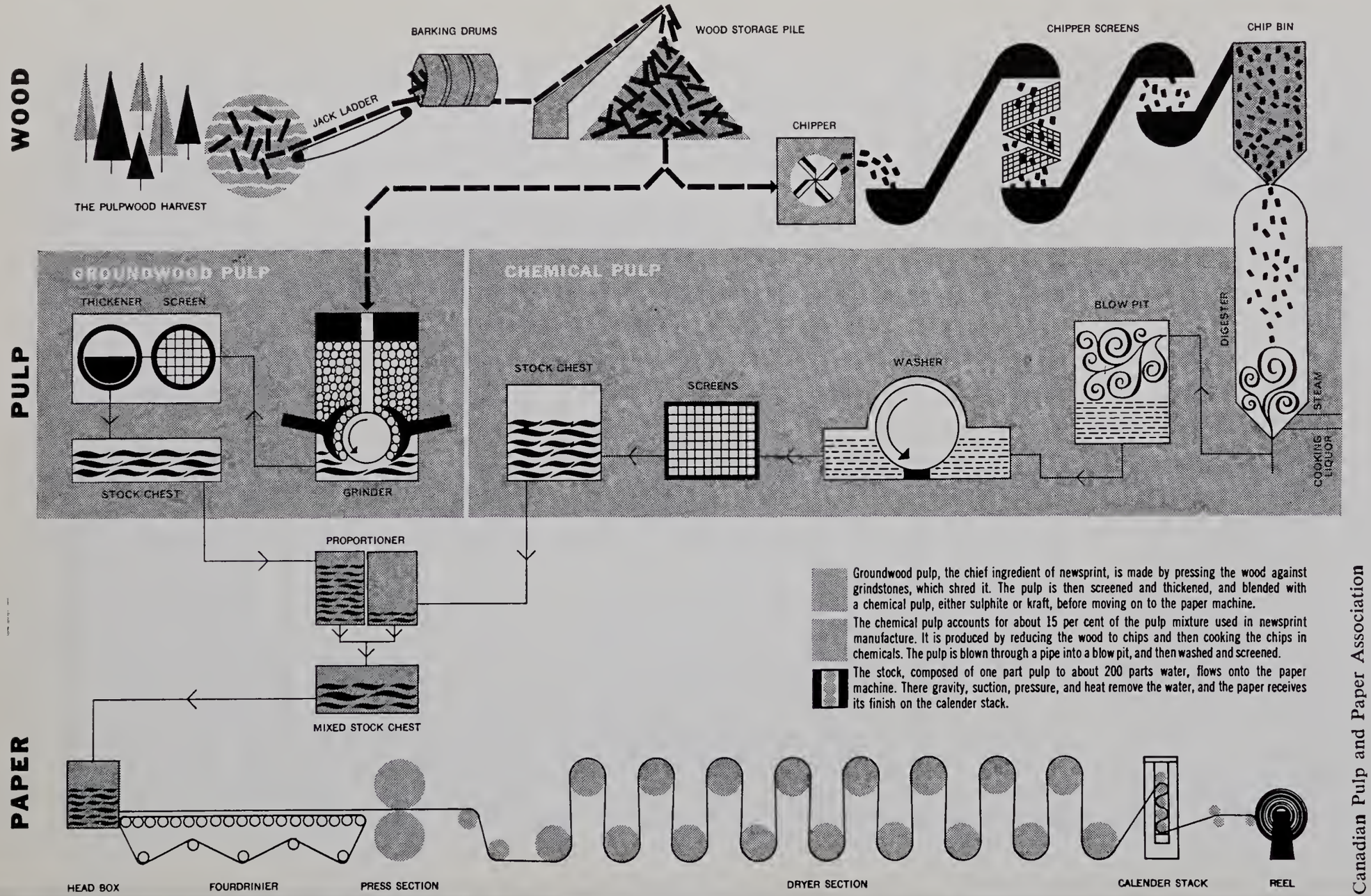
Research has found new uses for wood in such products as rayon, plastics, cellophane, plywood, fibreboard, wallboard, and laminated board. Many of these materials can be made from inferior trees and inferior grades of wood, and from by-products that were formerly wasted. Ways have been found to recover turpentine, alcohol, tanning liquors, and many other valuable chemicals from the waste products of pulp-mills and sawmills. Research along these lines is one of the most effective means of conservation, for it ensures the most efficient and beneficial use of our forest resources and at the same time helps to reduce waste and pollution.

The contribution of the forests to the nation's growth and to its present economy is almost immeasurable. Besides employing hundreds of thousands of people directly, the forest industries keep an army of workers busy in other industries and in such essential services as transportation and power production. The export of wood and wood products provides more foreign exchange than any other industry, and this exchange pays for much of the merchandise we import.

We must not think that the only value of the forest is in

HOW NEWSPRINT IS PRODUCED

Newsprint is by far Canada's chief export product, and the machines which manufacture it are marvels of man's mechanical ingenuity. Altogether, they are capable of producing each hour, day and night, the equivalent of a five-foot ribbon of paper stretching for nearly 7,000 miles from Toronto to well beyond Bagdad.


WOOD
THE PULPWOOD HARVEST
JACK LADDER
BARKING DRUMS
WOOD STORAGE PILE
CHIPPER
CHIPPER SCREENS
CHIP BIN
PULP
GROUNDWOOD PULP
THICKENER
SCREEN
STOCK CHEST
GRINDER
CHEMICAL PULP
STOCK CHEST
SCREENS
WASHER
BLOW PIT
DIGESTER
STEAM
COOKING LIQUOR
PROPORTIONER
MIXED STOCK CHEST
PAPER
HEAD BOX
FOURDRINIER
PRESS SECTION
DRYER SECTION
CALENDER STACK
REEL
Groundwood pulp, the chief ingredient of newsprint, is made by pressing the wood against grindstones, which shred it. The pulp is then screened and thickened, and blended with a chemical pulp, either sulphite or kraft, before moving on to the paper machine.
The chemical pulp accounts for about 15 per cent of the pulp mixture used in newsprint manufacture. It is produced by reducing the wood to chips and then cooking the chips in chemicals. The pulp is blown through a pipe into a blow pit, and then washed and screened.
The stock, composed of one part pulp to about 200 parts water, flows onto the paper machine. There gravity, suction, pressure, and heat remove the water, and the paper receives its finish on the calender stack.

Canadian Pulp and Paper Association

supplying raw material for the wood-using industries. Tourists and sportsmen who come to hunt and fish in our forests spend a great deal of money on goods and services. At one time the tourist business was restricted to the summer months and the hunting season, but now Canada's attractiveness as a winter playground has been discovered and tourism has become a year-round business. Hydro-electric plants providing us with heat, light, and power are dependent upon the water that falls upon the land and the forests that store and regulate it. Where there is not sufficient forest cover to regulate the water, very costly flood-control work may have to be undertaken.

In the more settled parts of the country, little forest remains except in the form of woodlots and shelter belts. Individually these wooded areas may be small, but taken together they make an important contribution to the economy and well-being of the country. They provide their owners with timber, fuel, and posts, and perhaps maple syrup, but their main value lies in their relation to water movement and water storage. In the woodlot nearly all the rain and snow soaks into the ground. This helps to build up a great reservoir of water in the soil known as *ground water*. The upper surface of this saturated zone is called the *water-table*. When the water-table is high, moisture moving upwards by capillary action reaches the roots of plants and may be the means of sustaining crops through a dry period. Where there are no woodlots the water-table becomes lower, wells have to be dug deeper, and the ground water is no longer available to plants. Wooded areas are especially valuable at the headwaters of streams, where they regulate the flow of water and maintain it at a cool, even temperature.

Too many owners fail to realize the value of their woodlots and allow them to be cut down for ready cash, or doom them to extinction by letting cattle graze in them. On the other hand, careful management has proved highly profitable for many small owners, and could be profitable for many more if they understood how to take care of their woodlots and realized the importance of doing so.

QUESTIONS

1. What was the attitude of the explorers and the earliest settlers toward the forest?
2. How did lumber contribute to the growth of Canada during the nineteenth century?
3. Name at least six trees that are important for the production of lumber. Find pictures of these trees and learn to recognize them.
4. Look up in the Canada Year Book the latest figures for lumber production in each province.
5. What is Canada's greatest money-making industry? What is the annual value of its production and how much does it export?
6. How much of the world's newsprint is obtained from Canadian forests?
7. Name six new uses for wood that have been developed by modern research.
8. Name some valuable chemicals that are by-products of pulp-mills and sawmills. Give two reasons why the recovery of these chemicals is important.
9. Name some values of the forest not connected with the supplying of raw material for industry.
10. In how many ways are woodlots valuable to their owners and to the countryside in general?

PART IV: THE FOREST

22 Forest and Wild-life Management

Since the products of the forest are so valuable and so necessary to us, we use them extensively, and in using them we cannot help upsetting the careful balance that nature has established. However, we can do a great deal to compensate for our interference by wise management of the forest and the wild-life that is associated with it.

The purpose of management is to make the forest continuously productive by proper methods of harvesting and by assuring conditions best suited to the growth of a healthy crop of trees. The management of a forest should therefore operate on many of the same principles as the management of a farm. An important difference, however, is that trees grow slowly and the time between harvests may be very long indeed, perhaps longer than a lifetime. For this reason there is a tendency for selfish individuals or companies to exploit the forest ruthlessly for immediate gain with no consideration for the future. "Why should we care about regrowth," they say, "since we will not live to profit by it."

Selective cutting and regeneration help to preserve our forests.
U.S. Forest Service

Of course, if we cut the forest clean or cut it carelessly, destroying all the young trees and burying the seedlings under heaps of slash, it *will* be a very long time before another crop develops. With proper management this need not happen. In the forest there are trees of many different ages, and a wise procedure is to cut only the mature ones that would soon die and rot if they were not used. Old trees weakened by disease or insects should also be removed without damaging the young growth surrounding them. In this way mature trees are utilized before they begin to decay, and the growth of the younger trees is accelerated by providing them with more light and space.

In a well-managed forest the broad stumps left by the lumbermen are surrounded by a vigorous growth of new trees of varying sizes. This method of management, known as *selective cutting,* has several other advantages: it ensures that the water-holding capacity of the forest will not be diminished and that the land will not be exposed to erosion; it ensures that the habitat of wild-life will not be seriously disturbed; and it permits a new crop of mature trees to be harvested every few years.

In some woods the trees are all about the same age, and under certain circumstances it may be advisable to cut them all at the same time. However, if this is done there will be very little natural regrowth and the area may have to be reforested artificially. In many cases it is a better policy to leave selected trees, sometimes singly and sometimes in groups, to re-seed the land by the natural dispersal of their seeds. This regrowth of the forest from seed trees is known as *natural regeneration* and has been very successful in many cut-over regions.

The long-range approach to the problem of forest management involves (1) finding the location and quantity of timber useful for different purposes – in other words, taking a forest inventory; (2) deciding how much of this timber can be cut each year without leading to permanent depletion. Aerial photography provides an excellent method of conducting a survey of forest resources. When aerial photographs are made,

two pictures are taken simultaneously at different angles and then examined under a stereoscopic viewer. In this way a three-dimensional effect is produced; contours of the land can be seen and even the heights of the trees fairly accurately determined. Based on exact knowledge of our forest resources, cutting should be planned with a view to obtaining a new crop and even improving the next crop by the elimination of trees of little value and encouraging the growth of more desirable species.

Supervising the growing and harvesting of trees is only part of the forester's job. He must be constantly on guard against damage caused by insects, fire, or disease, and he must be aware of all the complex factors that have to remain in balance to keep the forest healthy. Forest management cannot be considered apart from wild-life management, for, as we have seen, all forms of life, both plant and animal, that make up the forest community react upon one another in a variety of ways. Too many deer would hamper the natural reproduction of the

The white-tailed deer is one of the prettiest of Canada's wild animals.

Ontario Department of Lands and Forests

forest and a scarcity of certain birds could subject it to a plague of insects. It is therefore important that the forester and the biologist work together to try to maintain a proper balance between the various forms of animal life and the forest that provides them with food and shelter.

To the fur-traders and early settlers the wild-life, like the forest itself, seemed inexhaustible. Fish, fur-bearing mammals, marsh birds, deer, bear, moose, grouse, and even wild turkeys were in great abundance. However, as time went on and settlement advanced, the wild-life was forced back into more remote areas and some of the more vulnerable forms were completely exterminated. It is our duty now to reverse this trend and apply the principles of wise management to the preservation of wild-life and the kind of environment in which they can thrive.

Good wild-life management seeks to prevent excessive destruction of game and to relate the numbers of animals to the ability of the area to support them. One way to do this is to establish and enforce laws governing hunting and fishing seasons, bag limits, wolf bounties, and the size and number of fish that may be taken. However, law enforcement in itself is not enough. We must make sure, through the medium of education, that people understand the need for these laws so that they will willingly obey them. Another phase of wild-life management is the artificial propagation of certain species to be released in areas where they have become scarce. Under certain circumstances there may be some value in doing this, but it is much more important to find the underlying cause and correct the conditions that brought about the scarcity in the first place. If the conditions that caused the original scarcity are still present there is little to be gained by introducing more individuals to suffer the same fate as their predecessors. We have already mentioned the futility of planting fish in lakes or rivers where conditions have become intolerable to them. The same would apply to releasing partridge or pheasants in areas where there is insufficient food or cover, or where there are too many predators.

Neither law enforcement nor artificial propagation can have much effect in preserving wild-life if the food and shelter requirements of the various species are not maintained. It is clear, therefore, that the management of the environment is the most important factor in wild-life management. All attempts to restore game or fish to an environment that has ceased to be suitable are doomed to failure unless the environment itself is first restored to normal.

Food is one of the first considerations in determining how many animals can survive in a given area, and it is the amount of food available in the winter that is usually the decisive factor. Any given area can support only a limited number of individuals, so that each section of the forest has a definite *carrying capacity* for each species of wild-life. If the carrying capacity is reduced or if the numbers increase beyond the carrying capacity, starvation, disease, or predators will take their toll. Deer, for example, depend largely on cedar to sustain them during the winter months, and if too much cedar is removed by lumbering operations the deer herds in the district will be reduced by starvation and will in turn destroy a great many seedlings and young trees that they would normally not molest.

Lumbering operations are not always detrimental to animal life. In fact they may be quite beneficial if carried out according to the principles of good forest management. Many forms of game, such as grouse, deer, and moose, do not thrive in a forest of large mature trees where there is a scarcity of food and also a scarcity of places to hide from their enemies. When these forests are cut down and a young second growth develops there is much more food available and much better protection. If a forest is managed on the principles of selective cutting, food and cover for game can be maintained at a nearly constant level, which is very much better than alternate periods of scarcity and plenty.

From these considerations it is evident that the most important factor in wild-life management is the preservation of suitable habitats where food and shelter may be found. Where

The treatment of stream banks is simple and inexpensive. A severely eroded stream bank (above) is sloped; willow poles and cuttings are placed and planted (below). In a few years streamside vegetation will shade the stream, making a cool habitat for fish, holding the bank in place, and producing home, cover, and food for birds.

U.S. Forest Service

the natural habitat has been destroyed or impaired, the best thing that can be done is to restore it as nearly as possible to its original condition. If this is done and if wise game regulations are in force, nature will quickly replenish the area to its normal carrying capacity.

There are many ways of restoring, and sometimes improving, the natural habitat. Water-levels can be brought back to normal if interference with the drainage area has adversely affected fish, aquatic birds, or mammals. Such habitat improvement often has spectacular results, as was shown by the restoration of the marshes on the delta of the Saskatchewan River. Here, in one area where a census was taken, it was found that the number of muskrat houses increased from less than 100 to 11,000 in a period of three years. The planting of wild rice in areas such as this is another form of habitat improvement – one that has been of great assistance in the conservation of migratory wild-fowl.

Habitat improvement may also have very beneficial results in the case of streams and lakes. Here an obvious improvement would be the elimination of pollution wherever it is known to exist. In the case of streams, shelter and shade for fish can be provided. Deep pools can be formed by controlling the flow and direction of the water, or by obstacles suitably placed in the stream. Gravel spawning-grounds can be provided and desirable aquatic plants introduced. None of this work, however, should appear artificial. It should simply be a matter of using human ingenuity to help nature repair the damage caused by human mismanagement. The improvement of lakes and streams actually calls for the improvement of the whole environment, for it is the drainage area that controls the quantity of water, its temperature, and the extent of sedimentation. The restoration of swamps and marshes at the headwaters of a stream, the reforestation of the surrounding area, and the building of farm ponds are among the most effective methods of maintaining healthy water conditions.

Reforestation is undoubtedly the most effective form of

habitat improvement; in fact, without the forest the habitat for most forms of wild-life would simply not exist. Not only does the forest provide the conditions necessary for the existence of wild-life, but it also plays, as we already know, an indispensable part in the regulation of water and the prevention of erosion (Chapters 10 and 16). For this reason, every province carries out an extensive programme of reforestation. But in spite of the millions of seedling trees that are planted each year, submarginal areas and waste lands are increasing, wild-life in many areas is becoming scarcer, and erosion and flood continue to do their work of destruction. The establishment of River Valley Conservation Authorities has done much to hasten the work of reforestation, but we are still replanting trees at much too slow a rate to meet the need.

There is a good deal of evidence to show that about twenty per cent of the land in agricultural regions should be kept under forest cover. Far from reducing the productivity of the land, such wooded areas do much to increase it by preventing damage from drought, flood, and erosion. Besides acting as water regulators, wooded areas serve as sanctuaries for many forms of wild-life, including insectivorous birds, that are of great benefit to the farmer. Since most rural communities have considerably less than the optimum amount of woodland, it is imperative that the woodlots that remain should be carefully conserved and extended where possible.

In every rural area there are many odd areas or irregular pieces of land that should be planted in trees. Such areas include steep hillsides, sand dunes, gullies, abandoned roads, and awkward pieces of land cut off by rivers or railway tracks from the main part of the farm. If all such areas were planted with trees or shrubs they would provide excellent nesting-places for song and insectivorous birds, as well as cover and food for grouse, pheasants, or rabbits. Wild-life borders may be used to advantage where there are narrow strips of land unsuited to the growth of grain crops. Such strips may be developed as wind-breaks, as borders along streams or ditches, around farm ponds, or along farm roads and fences. If we

U.S. Forest Service

This gully apparently started years ago from field and road drainage. Lone grass was planted on the contour one year before this photograph was taken.

utilize every piece of waste land and abandoned farm in this way the health, beauty, and prosperity of the entire countryside would be greatly improved.

On a larger scale the national and provincial parks serve as forest preserves and wild-life sanctuaries. The first national parkland was created in 1885 at Banff in the Alberta Rockies, and seventeen other scenic areas have since been set aside as national parks. In each province, also, a number of parks have been established as a means of preserving the original forest and the scenes of beauty and interest associated with it.

In planning the management of forests and wild-life we should not be motivated simply by concern for the money obtained for timber, fur, or hunting licences. The woods and their wild-life have values that cannot be measured in terms of money – values for the naturalist, the artist, the photographer, in fact everyone who appreciates the privilege of ob-

serving and enjoying the beauties of nature. What a dull world it would be without the woodlands and their carpet of wild-flowers; without the chatter of squirrels, the flash of the blue-jay, the tapping of the woodpecker, and the music of song-birds.

When you walk in the woods I want you to see
The floating gold of a bumble bee,
Rivers of sunlight, pools of shade,
Toadstools sleeping in mossy jade,
A cobweb net with a catch of dew,
Treetop cones against the blue,
Dancing flowers, bright green flies,
And birds to put rainbows in your eyes.

ANONYMOUS

QUESTIONS

1. What is the purpose of forest and wild-life management?
2. Explain the terms *selective cutting* and *natural regeneration.*
3. Why is it important to make a survey of forest resources? Describe how such a survey might be carried out.
4. Indicate the location of the provincial parks on an outline map of your own province.
5. What are the advantages and disadvantages of artificially propagating wild-life species?
6. What is meant by the *carrying capacity* of a section of forest land? What happens if the carrying capacity is decreased or destroyed?
7. Describe at least three methods of restoring the natural habitat.
8. Make a list of improvements brought about by the reforestation of poor agricultural land.
9. What percentage of forest cover is considered desirable in agricultural areas?
10. Why should woodlots be fenced? How should they be managed to make them most productive?
11. Using the handbook *Canada* or the Canada Year Book, construct a table showing the national parks of Canada, their location and extent.

PART IV: THE FOREST

23 Protecting the Forest

The forests have many enemies threatening their existence. We all realize that great destruction is caused by forest fires, but we often forget that the damage caused by insects and disease is considerably greater.

Insects that destroy or damage trees by eating the leaves are called defoliators. Examples of these are the spruce budworm, the various sawflies, the hemlock looper, the Douglas fir tussock moth, and the balsam woolly aphid. Other insects such as bark beetles breed in the inner bark of trees, especially trees that have been defoliated or weakened by drought or disease. Then there are wood-boring insects that penetrate deep into the wood and continue their work of destruction long after the tree has been sawn into logs or timber.

One method of controlling insect pests is by aerial spraying with insecticides such as D.D.T., but these applications have to be on such an enormous scale that it is difficult for them to be completely effective. There is also the danger that the insecticides or poisoned insects might prove fatal to birds and deprive us of our best allies in the fight against forest insects.

Another way to combat insects is by means of insect parasites and predators. A number of these are native to Canada and others have been imported to help in the control of forest pests. Of the native species, a group of parasitic wasps known as "ichneumon flies" are especially valuable. The female has a long thin ovipositor like a stiff thread projecting from the end of the abdomen. With this ovipositor she can reach into tiny crevices or tunnels and deposit her eggs on the larvae of the host insect. When the eggs hatch, the ichneumon larvae devour the larvae of the injurious insect.

Predacious beetles and flies have done much to control the balsam woolly aphid which causes serious damage to the balsam fir. Parasitic wasps and flies are very effective in the control of the European spruce sawfly and the European larch sawfly. In connection with the introduction of parasites and predators many complications may arise, and great care must be exercised to make sure that we do not introduce insects that

Aerial spraying of forests with insecticides helps prevent the destruction of trees by insects.

might eventually become a greater menace than those they were imported to destroy.

The use of virus diseases to combat forest insects is a method that seems to have great promise for the future. Sawflies that were destroying Christmas tree plantations were successfully controlled by the spreading of a virus imported from Sweden. Another virus developed in Canada was used to control sawfly infestations in the northern jackpine forests. This type of biotic control has the great advantage that it does not affect any form of life other than the insects it destroys.

Tree diseases may be caused by bacteria, fungi, or by plant viruses. Blister rust of white pine, and Dutch elm disease are examples of diseases caused by fungi. Blister rust, like wheat rust, requires two hosts to complete its life cycle. The white pine is one host and a currant or gooseberry plant is the other. White-pine stands can therefore be protected by the removal of all the currant and gooseberry plants from the vicinity. In the case of the Dutch elm disease the fungus is carried from

Department of Agriculture, Ottawa

diseased trees to healthy ones by insects. The control of the disease thus depends on the extent to which we can control or suppress the insect carriers.

Another method of checking tree diseases is by breeding disease-resistant types, but this is a long, slow process because of the length of time it takes for trees to mature. Tree breeders, however, are attempting to shorten the life cycle by processes of grafting and forcing, and before long this may be one of our most effective methods of combating or eliminating certain diseases.

Scientists who study forest insects and the means of controlling them are called *forest entomologists,* and those who study diseases of plants are called *plant pathologists.* At the various universities and also at government laboratories across Canada, forest entomologists and pathologists wage a never-ending war against the most insidious and persistent enemies of the forest – insects and disease.

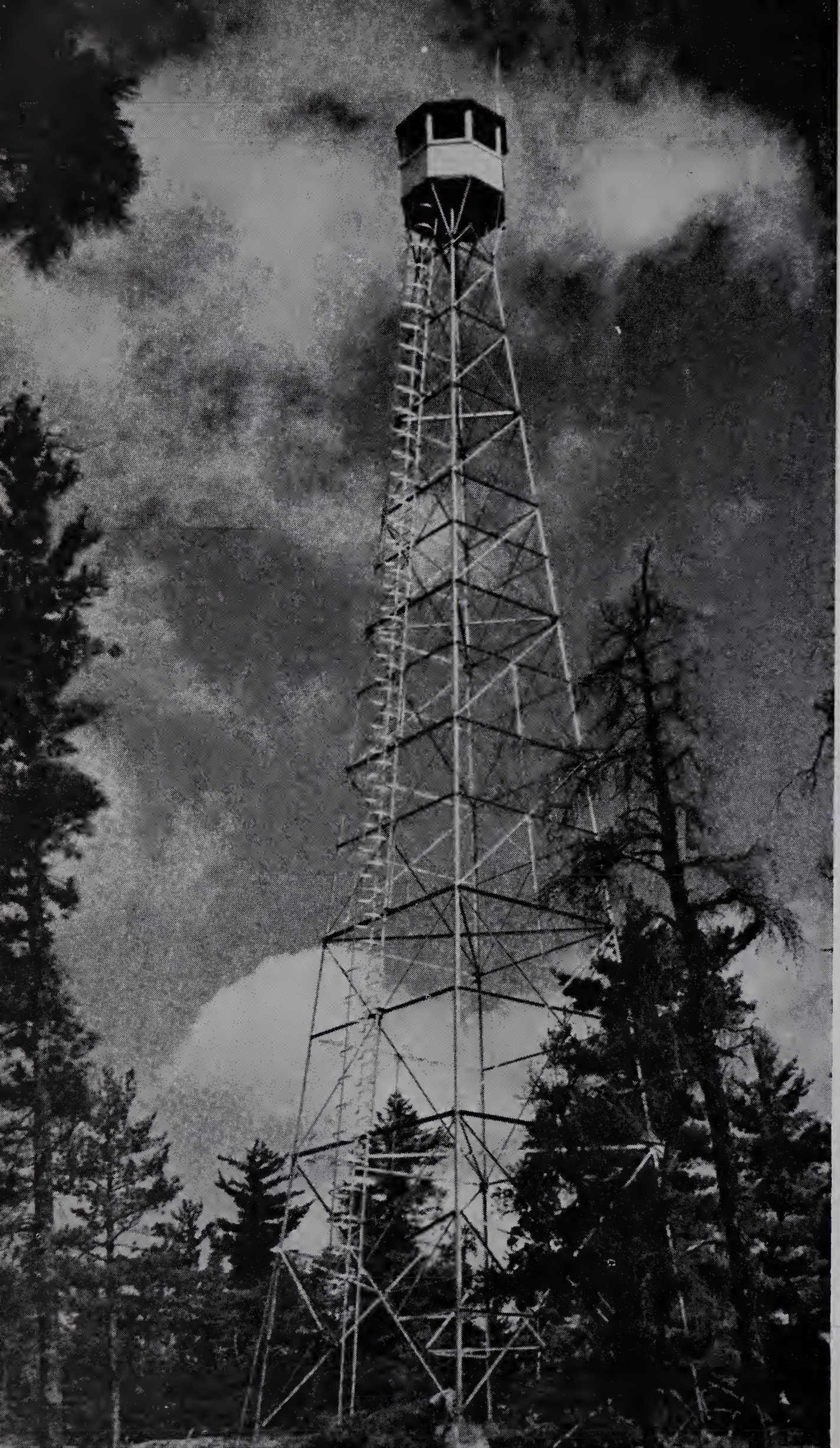
In spite of the enormous damage done by these tiny organisms, it is doubtful if they can rival man himself as a destroyer of forests. By clearing and abandoning poor land and by wasteful and indiscriminate cutting, man has ruined not only the forest but the very soil on which it grew – so that a thousand years might not be sufficient time to restore what he has ruthlessly destroyed. Besides this he is responsible for most of the forest fires that continue to destroy over two million acres of Canadian forest each year.*

Many great conflagrations of the past were caused by settlers' fires escaping into the surrounding forest. In 1825 a fire swept through the valley of the Miramichi River in New Brunswick, wiping out towns, villages, and farms. In 1907 a forest fire destroyed the town of Fernie, B.C., killing 25 people and rendering thousands homeless. In Ontario, the Porcupine fire of 1911 raged over half a million acres, wiping out several mining towns and killing at least 73 people. The great Mathe-

* In 1961 8,280,000 acres of forest were destroyed by fire. The next worst year on record was 1919 when 7,600,000 acres were burned.

It takes 50 to 100 years to grow an acre
of forest. Fifty seconds may doom it to ruin.
Canada loses 2½ million acres of
essential timber annually, to forest fires.
Accept your responsibility – help prevent forest fires!

Ontario Department of Lands and Forests



son fire of 1916 and the Haileybury fire of 1922 caused tremendous damage and great loss of life.

These are only a few of the disastrous fires that brought death and destruction to farmers, miners, and townspeople, and destroyed millions of acres of valuable timber and most of the wild-life of the region.

The fierce spectacular type of forest fire is known as a "crown fire" because the flames rush from tree to tree over the top of the forest. There are also surface fires that consume leaves, brush, or grass. A surface fire may destroy trees by scorching, even if it does not spread upwards and become a crown fire. Sometimes fires burn deep into the ground where there are deposits of peat or leaf-mould. Such underground fires can be very treacherous and are likely to break out on the surface long after the danger is thought to be over.

At the beginning of the present century, fire-fighting in Canada was in its infancy, and with few exceptions, organization for fire suppression was very simple or non-existent. Today each province has a carefully planned system of fire detection and control, and laws that provide penalties for neglect or carelessness.

Of course it is much better to prevent fires than to extinguish them after very serious damage has been done. For this reason laws have been passed to regulate the activities of people in forested areas. Such regulations usually include the following provisions:

(1) Certain areas are set aside as "travel permit areas". In them no one may enter or travel in the forest without first obtaining a permit. In this way, a check may be kept on people in the forested area.
(2) During the fire season (April to October inclusive), no one may burn slash or debris without first obtaining a permit.
(3) Work permits are required before persons or groups may undertake work of any kind in forested areas.
(4) In case of extreme fire hazard, certain areas may be completely closed to travel.

Fire towers like this one are found in most of Canada's forest areas.
Ontario Department of Lands and Forests

Laws and regulations such as these take account of the deplorable fact that the majority of fires are still caused by the carelessness of people in the forest, and they are designed to protect the people concerned as well as the forests themselves.

Fires have been known to originate from settlers burning slash, campers choosing a poor site for their fire or failing to extinguish it completely, smokers carelessly dropping matches or cigarette butts, carelessness with fire during logging, mining, or road-building operations, sparks from railway locomotives, and deliberate incendiarism. Fires not caused by human agency are usually caused by lightning.

Fire detection is based mainly on the combined operation of aircraft and look-out towers, a system that years of experience have proved to be the most effective. Most of the towers are steel structures 80 to 100 feet high, placed on carefully chosen hilltops so that great areas of forest may be under constant observation during the fire season. In the tower there is a detailed map with a sighting instrument called an *alidade* which enables the towerman to determine accurately the direction of the smoke he observes. Usually it is possible to observe the outbreak of fire from two widely separated towers and from these the information is instantly transmitted by radio. The reported direction of the fire from each of these points of observation is indicated by a thread stretched over a map at the Chief Ranger's headquarters. The intersection of these lines shows the exact location of the fire.

Once a fire has been located, speed is of the utmost importance. Every form of transportation may be employed, but aeroplanes, helicopters, trucks, and boats are most commonly used. Sometimes fire-fighters known as "smoke jumpers" are parachuted in to a fire, and parachutes may also be used to deliver supplies and equipment.

If the fire is not too far from a lake or stream, portable gasoline-powered pumps and long lines of hose are quickly brought into operation. If water is not available, hand tools or bulldozers may be used to isolate the fire by clearing a strip around it or in its path. This strip must be cleared of

inflammable material right down to the mineral soil. Hand-operated spray pumps are also used. These are fed by water from tanks that the men carry on their backs. Sometimes fires are "bombed" by bags of water dropped from planes or by water spilled from tanks attached to the pontoons.

Another method of fire control is the back-firing method, which simply means fighting fire with fire. A back-fire is usually started at a lake or stream when the wind is favourable to carry it towards the main conflagration. When the two fires meet, there is nothing left to burn, and no further spreading takes place – in that direction at least.

Over the last twenty years there have been great improvements in the methods of detecting and controlling forest fires. There have also been great advances in the development of equipment such as light and efficient power pumps, light and

Planes are used to drop a mixture of water and borate as one means of suppressing forest fires.

U.S. Forest Service

compact fire hose, radio and telephone apparatus for instant communication, and planes and helicopters designed specifically to meet Canadian forestry requirements.

Carrying equipment through the bush is still one of the hardest tasks faced by fire-fighting crews. To ease this burden and speed the delivery of essential equipment, small tractors and bulldozers have been designed that can be broken down, transported by aircraft, and reassembled near the site of the fire. The maintenance of all this fire-fighting equipment involves a great deal of costly and exacting work, since every unit must be kept at peak efficiency and ready for any emergency.

During the fire season the forester and the meteorologist combine their skills to keep a close check on conditions that increase or decrease the fire hazard, so that a condition of maximum preparedness can be maintained when the danger of fire is greatest.

Although great advances have been made in the technique of detecting and extinguishing fires, we must remember that the most this can accomplish is to decrease the damage after a fire has been discovered. There is only one sure way to stop fire losses and that is to prevent fires from starting. This can only be accomplished by the co-operation and vigilance of the people of Canada and their summer visitors. When we consider that the number of fires has been increasing at the rate of about one and a half per cent per year, and that more than eighty per cent of all forest fires are attributable to human carelessness, it becomes apparent that the real solution of the problem rests with ourselves.

> *We must take no chances with fire when camping or hunting in the forest or when driving through forested areas, and we must insist that others be equally careful.*

We should not leave the topic of forest fires without noting that under certain circumstances fire can have beneficial effects. In the virgin forest, fire often prepared the way for a new crop of timber by removing diseased, insect-infested, or

Hoses with fog nozzles are used by many fire fighters in Canada.
Ontario Department of Lands and Forests

over-mature stands, and foresters today are learning how to use fire to good advantage in their work of forest management. Sometimes fire is used on small tracts to prepare seed beds and encourage natural regeneration. It may also be used to prepare areas in advance for tree planting. This deliberate use of fire is called "prescribed burning", and although a great deal of research remains to be done, it has already proved to be beneficial in many ways when expertly handled. Of course work of this kind demands great skill and caution and is never used unless conditions are ideal for its control, for no one knows better than the forester that "fire is a good servant but a poor master".

QUESTIONS

1. What are the three great enemies of the forest?
2. Name five insects that are destructive to the forest, and indicate the type of tree attacked in each case. What name do we apply to a scientist who studies forest insects?
3. What organisms cause tree diseases? Name two tree diseases; describe how they spread and how they might be controlled. What name do we apply to a scientist who studies plant diseases?
4. Could man be classified as an enemy of the forest? Give reasons for your answer.
5. Name three great forest fires in which many lives were lost. Give the location of each fire and the date when it occurred.
6. Name three different kinds of forest fire and describe the characteristics of each.
7. What regulations have been made to prevent the outbreak of forest fires and to protect people in the forests?
8. What are the present-day methods of detecting a forest fire and accurately locating its position?
9. Describe the various methods used to control and extinguish a forest fire once it has been located.
10. Make a list of known causes of forest fires.
11. What percentage of forest fires is due to human carelessness or neglect? What can be done to reduce the number of forest fires?

PART IV: THE FOREST

24 The Forest Fire

HOW JIM McRAE AND BROTHER DAN
ESCAPED THE PORCUPINE FIRE*

The summer of 1911 was hot and dry. The forest which ringed the new settlement was tinder dry. A grey haze lay like thin gauze across all the land, causing the horizons to press closer in.

By day the face of the sun in the cloudless sky above the new gold camp had changed from the normal fiery white, first to yellow gold, and finally to the reddish hue of copper. Experienced pioneers were reading the signals. Each day their sensitive nostrils were measuring the increasing saturation of smoke in the air. Each night they scanned the sky where the flaring bush fires along the south-westerly horizon beaconed their ominous message of the increasing danger.

On July 10, a thermometer on the shady side of the drug store registered 107 degrees. All day long the smoky haze that now engulfed all the land had continued to thicken until

* Reprinted from *Call Me Tomorrow* by James A. McRae, by permission of the Ryerson Press.

by late afternoon it had completely blotted out the sun.

Many anxious heads lay on pillows that night in Porcupine. Not once did I hear a player-piano anywhere tinkling out its usual rhythmic call to fun and revelry, nor the squawking blare of a phonograph. Instead a hush as of some impending crisis silenced everybody and everything. In the trees which towered above my cabin no night birds chirped. The forest itself, drooping in the unprecedented heat, had also become a part of the all-embracing silence.

My cabin had become an oven. Recognizing the futility of sleep under such conditions, we sat beneath the trees outside and talked far into the night. There with our boots and socks removed we twiddled our feet in the soothing water of Porcupine Creek which flowed close by the cabin door. . . .

The hot smoke was beginning to reel about us where it now billowed low among the trees. Visibility had been rendered difficult for our bloodshot eyes as we rushed towards our waiting canoe.

Even as we pushed the little craft toward the middle of the stream, the flaming limb of a tree came spinning down from the blackening sky above us. The burning piece hissed viciously as it fizzed itself out in the water an arm's length away.

A few quick strokes of our paddles, plied in unison, sent us speeding on our way. Ashes were falling all about like so many dirty snowflakes. We paddled hard. A live ember fell on the sleeve of my shirt and began to smoulder. The first intimation I had of its presence there was a biting sensation as of the sting of a bee. With the loss of not more than a single stroke of my paddle I doused the fire.

Now looming ahead of us was the wide open expanse of Porcupine Lake. In that moment of elation we permitted the canoe to scud of its own volition before the driving wind as we swept out through the mouth of Porcupine Creek.

Clear of the forest we could now look back. For a moment we stared in awe. Inland where my cabin stood was a wall of

inky smoke. Through the smoke the long tongues of flame could be seen, sometimes leaping high and wild as with a single flick of the fiery tongue the entire dress of a balsam or a spruce vanished. But our immediate concern was the chaos and confusion of wind and water and drowning men into the midst of which we had suddenly been transported.

Men in hundreds had waded into the lake at the front of South Porcupine. Many of them, with their feet mired in the ooze of the lakebed, were standing chin deep in the water. At frequent intervals, like so many turtles, they were drawing their heads beneath the surface for brief respites from the intense heat and smoke of the flaming shore.

The town itself had become a roaring inferno. Upon a rooftop, in terrifying silhouette, I saw one lone man hopelessly marooned. He was holding his arms high aloft as though pleading for mercy. Then I saw the roof cave in! I closed my eyes in a futile effort to black out what I had seen, then turned about to the lake itself.

Far out across the churning water I could see the bobbing heads of uncounted men. Some had used their leather belts to lash themselves to whatever floating object they could find – a log, a box, a wooden chair, or perhaps nothing more than a board. A few were clutching with bare hands to bales of hay which were fast becoming waterlogged.

It was not difficult to see that many of those afloat were drifting to their doom in the wild turbulence of the lake farther out. Also there was no way of knowing how many of those who now wallowed in the mire of the lakebed nearer shore would survive.

In an effort to escape the heat at the immediate front of South Porcupine, various stragglers had waded their way along the shore to where Porcupine Creek emptied in. There they were quick to see our canoe when we glided out through the mouth of the creek. One little group of three or four men were looking our way with obvious envy. And before we realized what they were up to, they were floundering toward us.

The canoe was a 16-footer. Two was a load, especially in the heavy seas sure to be encountered on leaving the lee of the shore. Quickly plying our paddles, we were just in time to manoeuvre clear of the frantically clutching hands. We knew that to allow four more aboard would be to save none, including ourselves. I sympathized with the distraught men in their desperate flight, but it was not an occasion for hesitation or palaver.

However, in veering wide and clear of the hostile group, I had steered the canoe close to where a lone man stood. He was in water to his armpits. We had brushed almost against him. He was staring hard at the canoe, his face haggard and drawn. Yet he made no effort to so much as clutch at the gunwale.

Then when I looked into his face again, I recognized the man. His name was Tom Powers. His home was in Haileybury. I had met him at the Haileybury home of his niece.

From my place in the stern I plied my paddles so as to arrest the canoe in its flight.

"Should we take a chance on one more?" I said to Dan.

"Sure-sure," Dan said, without hesitation, yet knowing full well that in doing so we were inviting disaster to ourselves.

"All right, Tom," I said. "Crawl in." His eyes bespoke his thankfulness as he clambered aboard.

We were now moving from the lee of the land. We were fast gaining momentum, whipped upon our way on the wings of the wind. To the right and the left of us we could see men struggling in their efforts to cling to their floats, some frail and some unwieldy. And before we had advanced far down the lake, we realized that the violence of the storm was going to be more than we ourselves had bargained for. But we had no hope now of making our way back into the teeth of such a gale.

Nor was it man alone that was in distress. Round about us now were animals of the forest, swimming about in wild-eyed desperation. Pommelled and harried in the violently surging

waves, man and beast were milling about together and with each species seemingly unmindful of the presence of the other in their hour of peril.

At one stage as we slewed forward on the crest of a white-capped wave, Dan in the bow could see that we were headed straight into the swimming path of a huge black bear. There was no possibility of veering away. Accordingly, taking the only evasive action that he could, Dan stabbed the blade of his paddle straight into the oncoming bear's face. Undaunted, the determined animal reached one of its huge claws toward the gunwale of the canoe. But Dan, in desperation, again thrust out his paddle, this time with sufficient accuracy to smack hard against the bared teeth of the frantic beast. For one brief instant the little canoe yawed precariously, calling upon every ounce of my strength and ingenuity to avoid capsizing. In the next instant an oncoming wave had swept us to safety from the flailing claws. There had been no time for comment. Not a word had been spoken.

Scudding before the gale, the turmoil of the churning water was increasing with each moment of our progress. We were careening wildly on the forward rush of the foaming crests, then settling ominously low in the deep troughs.

From my point of vantage in the stern, I could see the extent to which our little craft was beginning to take water, and that with three men aboard we were asking too much of the little canvas-covered canoe, a frail thing indeed, weighing not more than seventy pounds.

So strong was the wind that it sometimes picked the crests from the waves and sent the wind-borne water showering about us. I could see that our passenger was now bailing as fast as he could, but I could see that he paused occasionally to allow one hand to mark out the sign of a cross at his chest.

We were travelling in a course parallel to the south-east shore of Porcupine Lake. And the fact that the forest in that direction was all ablaze as far ahead as could be seen, had suggested to me that the vast conflagration must be roaring

north-eastward at a rate of at least thirty miles an hour.

Water sloshing about my knees where I knelt in the stern came as a clear announcement of our losing battle. I knew now that we could not complete the journey to Golden City. But continue we must in the effort. . . .

Meanwhile, I had been closely scanning the south-east shore which paralleled our course on the right. There I had caught sight of a little point of land which jutted sharply out from the shore. The little projection, although dimly visible through the haze and smoke, appeared to be of solid rock, bald and barren. Instinctively, it seemed, I feathered the blade of my paddle so as to cause the bow of the canoe to veer shoreward.

From his place in the bow I could see that Dan was instantly assisting me in our change of course.

"Good work, Tom!" I shouted, encouragingly.

"Keep her afloat another five minutes and we'll make it!"

On closer approach we could see that the cove behind the rock was extremely small, yet because of that would provide almost perfect refuge from the howling wind and raging sea. In the next few minutes we paddled safely in. . . .

And good indeed was our haven, the sheltered inlet itself as well as the bald point of rock upon which we landed. It was an island of refuge devoid of any form of tinder which could burn, hemmed in on the one side by the storm-torn lake, and on the other by the burning wreckage of that which but an hour ago had been dense and virgin forest.

Throughout the remainder of the day we were content to lie upon the rocks, weary but safe. Thanks to Dan we ate ravenously of the grubstake which he had the foresight to place in the packsack.

By the time the light of day commenced to fade, the wind also had died down to a whisper. The forest fire no longer raged, for the very simple reason that the central area of the Porcupine gold-field no longer contained inflammable material for fires to feed upon.

Through the thinning smoke and haze the early stars seemed to blink down upon us with complete unconcern as we finally took to our canoe again. As we paddled in the night from our haven, it seemed scarcely possible that the surface of Porcupine Lake could have become so peaceful, so serene, so innocent, when we knew it had become the grave of so many men that very day.

When well out on the quiet lake we paused briefly to survey what lay around about us. The fire had come and gone, and had devoured all the forest as it went. Now in the night the barren hillsides continued to smoulder and smoke. An occasional stubborn stump or log still flamed spasmodically with here and there the flicker as of fireflies among the dying embers, now the only living thing in the midst of the ghastly devastation.

Wearily now we paddled our way to the landing at Golden City, that one little cluster of log huts which had so miraculously escaped the holocaust. There other survivors were beginning to straggle in. And from the lips of each came an individual chapter for Porcupine's book of tragedy and woe.

Gone were the mining towns of Pottsville and South Porcupine, as well as everything in the townsite of Schumacher and Timmins, not a board or a log remaining. Gone also were the mining plants which had been so hopefully erected, everything on the surface of the mines reduced to ashes or to twisted iron.

Gone too were the lives of scores of men, either snuffed out in the all-devouring flames or lying at the bottom of Porcupine Lake. Gone also was all the equipment and the uncounted cabins of the prospectors. Gone was everything that 1,200 teams of horses had been able to haul to the gold-field in an entire year, all whisked away into smoke in just one short afternoon. . . .

PART V: MAN AND NATURE

25 The Web of Life

It is often convenient to consider our natural resources under separate headings as you find them in this book. Nevertheless we are well aware that they do not really exist as separate and distinct units. They are, in fact, intricately interwoven with one another, and each one, if it is to be fully understood, must be studied in relation to all the others. We cannot properly understand the importance of water unless we see it in relation to the air and the soil, and to plant and animal life, nor can we realize the significance of erosion unless we see it in terms of human want and suffering.

Darwin referred to the interdependence of living things as the *web of life*. "Plants and animals most remote in the scale of nature," he said, "are bound together by a web of complex relations." He illustrated this by showing that the success of a crop of clover depends to a considerable extent on the number of cats in the district. Now, no one would suspect a relation-

ship between cats and clover, but a very definite one does exist. The clover is pollinated by the bumble-bee; the nests of the bees are raided and destroyed by field mice. When the mice are very numerous the bees are almost exterminated and the clover produces little or no seed. The cats, of course, keep the mice in check, allowing both the bees and the clover to flourish.

A little thought will reveal many other connecting threads between living things, where at first sight no relationship would be suspected. For example, the number of foxes in the barrens of the far north may determine the number of mice on a farm in southern Ontario. The Arctic fox lives chiefly on small mouse-like creatures called lemmings. The lemmings are also the staple food of the snowy owl. When Arctic foxes are numerous lemmings become scarce and the snowy owl flies south to feed on mice in the farmers' fields. We might go on here to show that the farm cats might then go hungry while the bees, the clover, the cattle, and the farmer prospered. Unfortunately many of the owls are shot by witless people who do not recognize a friend when they see one.

Within the web of life many clearly marked strands or "chains" can be seen. Some of these were discussed in Chapter 19 (The Living Forest), and you will recall that in each case the chain started with vegetation and ended with some carnivorous animal. If we examine the food-chain idea carefully we soon see that the lower the species is in the chain the greater its numbers must be; in fact it might be better to think of it as a *pyramid* rather than a chain. In a lake, for example, thousands of aquatic insects feeding on vegetation are necessary to sustain one minnow, hundreds of minnows are necessary to sustain one perch, and scores of perch are necessary to sustain one pike. In the forest, enormous numbers of mice are necessary to feed relatively few hawks, and large numbers of rabbits are needed to maintain a small population of foxes. This being the case, the animals at the base of the pyramid must be capable of enormously rapid reproduction, a fact that

can have very serious consequences if the usual checks are removed.

Within the web all forms of life are struggling not only to survive but to expand. Each thread of the web is constantly under tension, a tension that results from the balance of several opposing forces. Sometimes one of the forces becomes weakened, or the opposing force becomes too strong, and a strand breaks. When this happens a whole series of readjustments must take place, even in remote parts of the web, before a new equilibrium can be achieved. The tendency of a species to increase its numbers is an example of one of these forces, and the hostility of the environment can be seen as the opposing force.

The ability of any species to increase in numbers is called its *biotic potential.* Some organisms such as bacteria, insects, and oysters have a tremendous biotic potential, and if conditions were ideal they would soon cover the earth with their descendants. An oyster, for example, can produce about 500 million ripe eggs at one spawning. If all these matured and their offspring also matured, after only four generations there would be a mass of oysters about 8 times the size of the earth. This, of course, is quite impossible because of the powerful opposing forces that we call the *environmental resistance.*

In keeping animal numbers in check, several factors are important. One of the most effective of these is predation, the predators forming the peak of the food pyramid and preventing the rapidly multiplying species below from expanding beyond the ability of the land to support them. Competition is another factor. When numbers of animals become excessive they compete with one another for breeding-space and shelter. They also destroy their food supply faster than nature can replenish it, and are finally reduced again to numbers that are in keeping with the carrying capacity of the land. Many factors introduced by man make serious changes in the environmental resistance. Some of these are deforestation, cultivation, drainage of wetlands, destruction of predators, building of canals,

and the introduction of plants or animals to new territory.

If we increase the environmental resistance too much, some forms of life become scarce, and may even become extinct. On the other hand, if the environmental resistance is decreased for any reason, certain species may suddenly expand from a small to a very large population. Such population "explosions" are often seen in insect plagues, but they are by no means restricted to the smaller forms of life. In the case of a certain forest where most of the wolves were destroyed, the deer population increased from 4,000 to 100,000 in a period of 14 years. The result, of course, was that in a very short time nearly all the available food was consumed and the herd was drastically reduced by starvation. In this instance the role of the predator was apparently not understood, and the wolves were killed off in the mistaken belief that this would benefit the deer.

Many of our mistakes are made because of our failure to realize the complexity of the problems and our tendency to treat symptoms rather than underlying causes. We must remember that all our conservation problems are bound up together in the web of life and that *man himself is part of the web*. Wild-life management, soil conservation, water power, flood control, erosion, fisheries, and many other questions are not separate problems, but should be seen as inseparable, interwoven aspects of one central problem.

If we are to live in harmony with nature and manage our resources successfully we will have to study the web of life much more carefully than we have studied it already, and the results of such studies will have to be made known to the public at large. It is not enough that a few specialists discover what ought to be done. The public must be aware of the need for action, for it is public demand that will ensure that action is taken. In short, a great deal more effort will have to be directed to both conservation-research and conservation-education.

QUESTIONS

1. What is meant by the *web of life*?
2. Explain the relationship between the following:
   (a) Cats and clover.
   (b) Arctic foxes and farm mice.
3. Can you discover any relationship between:
   (a) Pine trees and gooseberries?
   (b) Snails and sheep?
   (c) Mosquitoes and the Suez Canal?
   (d) Black Bass and water power?
   (e) Mink coats and whales?
4. Give an example (not mentioned in this chapter) of (a) a cycle, (b) a food pyramid.
5. What is meant by (a) biotic potential, (b) environmental resistance? Give examples.
6. What is meant by a "population explosion"? Give examples.
7. If a single bacterium divides into two at the end of half an hour, and these two divide again in another half-hour and the process continues at this rate, how many bacteria will there be after 24 hours if they all survive?
8. Make a list of factors that help to keep the numbers of animals in check. Explain how parasites may influence environmental resistance.
9. Do you consider that nature is cruel? Give reasons for your answer.
10. Explain how man fits into the web of life.

PART V: MAN AND NATURE

26 Man's Place in Nature

Although man has many attributes that set him apart from the lower animals, he must never forget that he is part of the web of life and subject to the laws of nature. Since earliest times he has thought of himself as "the lord of creation" and has considered it his right to rule over every living thing, to consume the earth's resources, and to bend the forces of nature to his will.

What we need to realize now more than ever before is that the power to rule carries with it serious obligations and responsibilities, and that if man fails to use his power and his resources wisely he may be destroyed by the relentless forces he seeks to control.

Man, because of his superior intelligence, has developed weapons that place all the other creatures of the earth completely at his mercy; he has developed rapid means of transportation and can easily transfer plants or animals to locations far from their natural habitat; and most important of all, he

has developed powerful machines and explosives with which he can make drastic changes in the natural environment.

Even before the invention of great and powerful machines, man had the ability to destroy his environment and thus to destroy himself. Examples of this can be seen in the history of cities, empires, and civilizations that have passed into oblivion because their people ignored the inescapable laws of nature. The great civilizations that once centred around Babylon and Carthage or the great cities and temples of the Mayas were not destroyed solely by their enemies, although this may have been the final stage in their destruction. In archaeological records the story can be traced over and over again in Asia, Europe, Africa, and South America. The forests were cut down and the land eroded, the fertility of the soil was depleted faster than it could be replaced, productivity decreased, drought or flood caused further damage, and eventually famine, disease, and war brought complete and final disaster.

As time goes on and the earth's resources dwindle, the need to conserve them becomes greater than ever. At the same time, as a result of our great scientific and industrial advances and our rapidly increasing population, we are using up our resources at a far greater rate than ever before.

In 1798 Thomas Malthus wrote that the world's population would soon outrun its food supply, but the opening up of new countries and improved methods of agriculture soon made it appear that he was wrong. Now, however, with the world's population increasing very rapidly and no new countries to colonize, people are again beginning to think seriously about Malthus's theory.

Populations increase by geometric progression; that is, the greater the population the greater the increase in a given period of time. When the time required for the population to double also becomes shorter, the process is still further accelerated.

At the beginning of the Christian era, the world population

is estimated to have been less than 200 million. It took many centuries to double this number, but each successive doubling took place in a shorter and shorter time. By the year 1900 the world population was about 1.5 billion. Since then it has doubled in little more than 60 years, and it is predicted that the present 3 billion will become 6 billion by the end of the present century. We may get some idea of the significance of these figures if we realize that it took perhaps 200,000 years for the human race to reach the first 1.5 billion, but only 60 years to add another 1.5 billion. The present rate of increase is approximately 50 million per year, which is more than the entire population of France.

Such rapid increase in numbers is bound to meet with environmental resistance, mainly in the form of food shortage and serious competition between individuals and nations. Another factor is that the population is very unevenly distributed, and while two-thirds of the world's people struggle for the bare necessities of life the other one third live in comparative luxury. Such a situation is bound to cause dissatisfaction and tension, and many of the underprivileged nations are coming to demand a greater share in the world's resources. The United Nations calls this "the revolution of rising expectations", and through its various agencies it is trying to improve the conditions of the dangerously dissatisfied and destitute peoples of the world.

One of these agencies, the Food and Agriculture Organization (FAO), was formed in Quebec City in 1945 and has been working ever since to keep food production in step with population increase. In view of the rapid increase in population this is no easy matter.

Several ways have been suggested to increase the world's food production. Some of these are:

(1) By providing more fertilizer to increase the crop yield.
(2) By extending the area now under cultivation by means of drainage, irrigation, or clearing the jungle.

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"Snail fever" is another name for schistosomiasis or hilharziasis, which is one of the world's most urgent medical problems. This disease is caused by parasites from three specific types of snails. These parasites penetrate the skin of humans and animals and invade the blood stream. Here they produce many eggs, which progressively damage vital organs. An estimated 100 million people, most of them living in tropical climates, are now stricken by this debilitating disease. It spreads to new countries and afflicts more people every year.

(3) By adopting more efficient methods of cultivation, including the use of modern farm machinery.
(4) By building dams to supply water for irrigation.
(5) By substituting better breeds of animals, or varieties of crops which are more productive and more resistant to disease than those now used.
(6) By reducing the losses that occur in storage and during transportation as a result of spoilage or destruction by pests.
(7) Another way of increasing the world's food supply is by drawing more heavily upon the sea and utilizing more efficiently the catches of fish already being taken. Sometimes half a catch is thrown to the gulls or otherwise discarded because it is "trash fish" and has no commercial value, yet this "trash fish" contains valuable protein which the world badly needs. It has been shown that these fish can be used to produce a highly nutritious protein concentrate, and there is every indication that if this process came into general use it would become a major source of cheap protein. Besides the increased use of fish, it has been suggested that plankton and other marine vegetation could be utilized as food. In this connection it is interesting to note that by shortening the food chains leading to himself, man can avoid the rapid shrinkage of solar energy as it passes from one organism to another. For example, 1,000 calories as algae protoplasm produces only 30 calories as smelt protoplasm, 6 calories as trout protoplasm, and 1.2 calories as human protoplasm.

Canada, as a great wheat producer, can make important contributions to the world's food supply, but many experts believe that the problem cannot be solved simply by giving away the surplus foods of the more prosperous countries. These surpluses, they say, would be used up rapidly and the final condition would be worse than the first. The best method, it seems, is to provide expert help, machinery, and fertilizers,

and to encourage the people of the underdeveloped countries to help themselves. Since expert knowledge is of the utmost importance, perhaps we could contribute most by bringing foreign students to study at our agricultural colleges and experimental farms, or by establishing similar colleges and research stations in undeveloped countries.

There are many difficulties and dangers in all these attempts to make the earth yield more food, and unless it can be done on a *sustained-yield* basis we may be simply robbing the future to pay for the present.

Sometimes we forget about the web of life, or we do not know enough about it to foresee the consequences of our actions. For example, a costly irrigation scheme established in Egypt shortly after the Second World War turned out to be a complete failure and had to be abandoned because the planners overlooked a snail! This snail is host to a parasitic worm that spreads its larvae by the millions in the water of the irrigation ditches. The larvae, in turn, infect humans with a crippling disease known as "snail fever".

To solve the problems that face us now, we must first be aware of their difficulty and complexity; second, we must acquire more knowledge about nature and about ourselves; and finally we must apply this knowledge with foresight and intelligence.

QUESTIONS

1. Name three great powers that enable man to upset the balance of nature.
2. Give examples of civilizations that flourished for a while and then died out. What were some of the reasons?
3. Who was Thomas Malthus, and what was his theory? Why was it not generally accepted?
4. What is meant by a *geometric progression*? Give an example.
5. Describe the rate of growth of the world population since the beginning of the Christian era.
6. What is the present population of the world and how rapidly is it increasing?
7. What are some of the consequences of expanding world population?
8. Describe a number of methods by which the world's food supply could be increased.
9. Can the problem of food shortage be permanently solved by exporting surpluses from the more prosperous countries? Explain.
10. Describe possible ways by which Canada might assist the underdeveloped countries of the world.

PART V: MAN AND NATURE

27 The Balance of Nature

As we have seen, man is the great disturber of the balance of nature. Sometimes he makes conditions so difficult for a species that it becomes extinct. At other times he removes the obstacles that hold numbers in check, with the result that populations expand to plague proportions. Species that have become extinct are extinct for ever, and species that have spread and multiplied because of man's interference cannot be returned to their original habitat and their original numbers. Like the sorcerer's apprentice, we can set powerful and mysterious forces in motion but we cannot reverse them.

Perhaps the most spectacular example of the disappearance of a once plentiful species is that of the passenger pigeon. These birds once flocked in enormous numbers over a large part of North America, but following the settlement of the land they rapidly decreased and by 1914 not a single specimen remained alive.

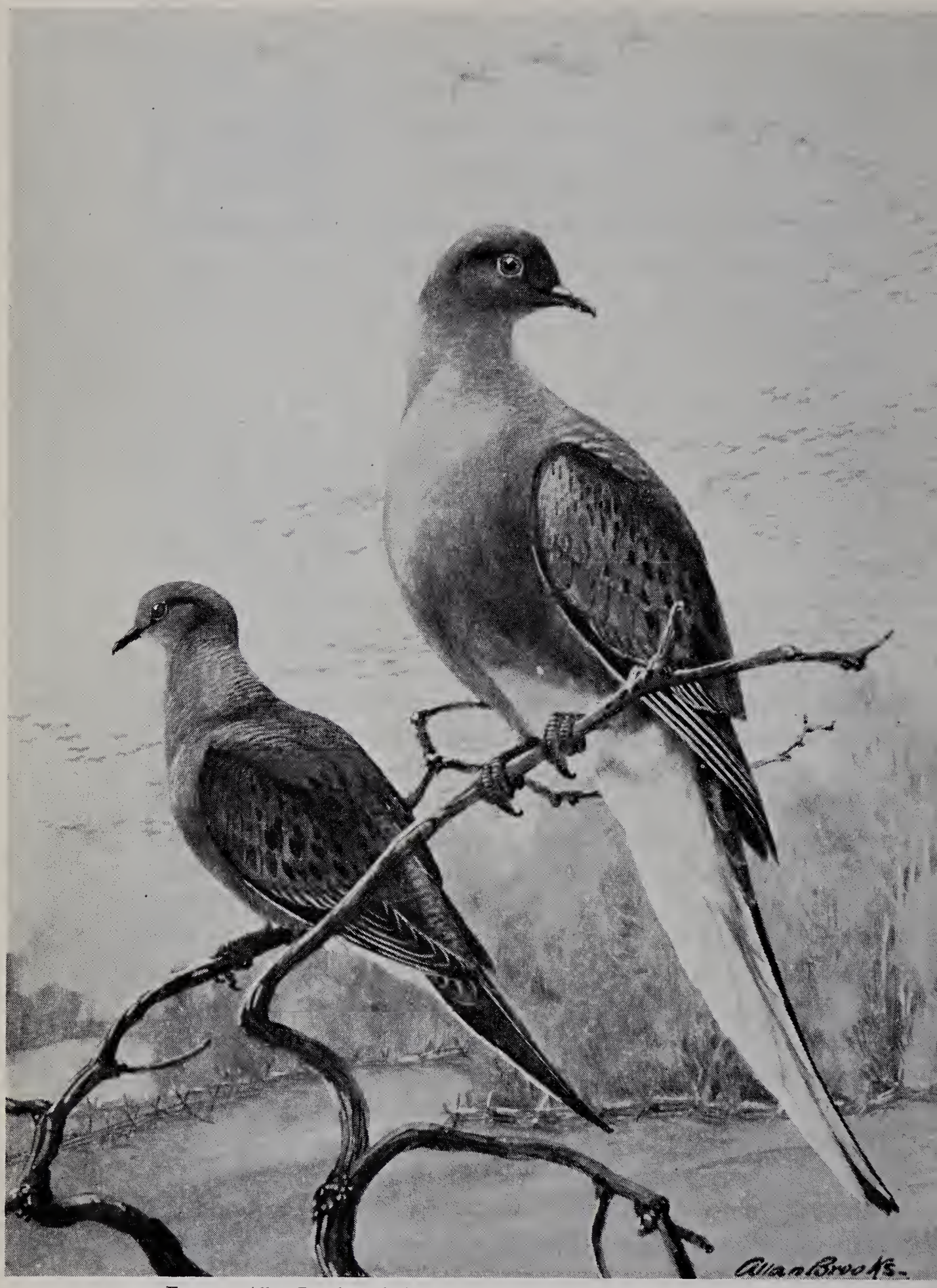
In 1929 Mr. N. Pearson, writing of his boyhood in the

region just north of Toronto, said, "My memory goes back as far as 1850 when as a boy I carried on to the best of my ability a relentless warfare of destruction on these innocent creatures, more in habit than intention or wickedness." He goes on to tell of their nesting in vast numbers, of their slaughter by the farmers from the country round about, and how his grandmother pickled and smoked them for winter use. Other observers tell of great flights like immense clouds extending as far as the eye could see and taking many hours to pass.

Although many birds were killed while feeding or migrating, the greatest destruction took place when the nests were filled with squabs, as the young birds were called. The nesting of such a multitude was an extraordinary sight. They usually chose hardwood trees and nested in great tracts several miles wide and 30 or 40 miles long. The constant calling of the birds and the fluttering of their wings made a deafening noise, and branches often broke from the trees, so heavily were they laden. At this time every man and boy in the neighbourhood turned out with guns, sticks, nets, and even sulphur pots and killed incredible numbers of the pigeons and their young. Many of them were pickled or salted for local consumption, but thousands of barrels and even freight-car loads were exported to the markets of the great cities.

Although the pigeons were a source of food and income to the pioneer they also caused him considerable loss. They fed on his crops, sometimes destroying whole fields of freshly-seeded grain in the spring, or the unharvested crop in summer. Farmers were not sorry, therefore, to see their numbers reduced, but they had no idea that any wild creature occurring in such abundance could be in danger of becoming extinct.

To many people the greatest mystery in connection with the passenger pigeon is its sudden and complete disappearance. The fact remains, however, that after 1898 only a few captive specimens remained. All attempts to perpetuate the species in captivity failed, and the last living passenger pigeon,



From an Allan Brooks painting, courtesy Royal Ontario Museum, University of Toronto

Once seen in flocks of thousands in North America, the passenger pigeon is now extinct.

"Martha", died in the Cincinnati Zoological Gardens in 1914.

Another bird that found it impossible to live under the conditions imposed by man was the wild turkey. This bird was well known to the early settlers in Upper Canada, but its existence depended upon the delicate balance that had developed through many centuries in the hardwood forests. This balance was rudely upset when the settlers began clearing the land, and it was not long until the turkey became scarce and finally disappeared. Although wild turkeys are not extinct (they still exist, rather precariously, in certain parts of the United States), it would be impossible to re-establish them in Canada since the environment they need no longer exists. There are no official records of the wild turkey in Canada after 1902. In that year Edwyn Sandys* wrote, "Thirty years ago one could drive in almost any direction through the woods of western Ontario and reasonably expect to see either the birds themselves or their tracks across the snowy roads. Twenty years ago the range had narrowed to the big woods of the western tongue of Ontario. Ten years ago the last stronghold had dwindled to the wildest parts of about three counties. Today, there is perhaps a single narrow strip where one might strike a trail and possibly catch a glimpse of a fleeing survivor of the old time hosts." The wild turkey was part of the forest community and without the forest it could not exist. Of course many of them were killed by hunters, but it was the axe rather than the gun that was the real culprit.

A species of bird about which there is a good deal of concern today is the whooping crane. The present population of this species is only thirty-eight wild birds and a few others kept in captivity. Whooping cranes are very large birds, standing five feet high and having a wing spread of about seven feet. The few wild birds that remain winter in Texas and then fly to the Northwest Territories for the summer, which is their

* Reprinted from *Upland Game Birds* by Edwyn William Sandys and T. S. Van Dyke, published by The Macmillan Company, New York, 1924.

nesting season. For a long time their nesting sites remained undiscovered but they are now known to nest in Wood Buffalo National Park near Great Slave Lake. Great care is taken to prevent them from being molested, and there is some indication that the population may be slowly increasing. Eggs have been hatched at the Audubon Park Zoo at New Orleans, but it is uncertain whether the young can be raised successfully in captivity.

There is a good deal more optimism about the trumpeter swan, whose numbers were down to seventy-three in 1935. As a result of careful protection it is gradually coming back and we can be reasonably sure that the danger of extinction is past. In 1955 the population was estimated at 1,500, and the present total is believed to be about 2,000. In the early days the trumpeter was hunted for his feathers and his meat. The down was used for bedding and the great wing feathers were used to make quill pens. In Canada the trumpeter is seen more particularly in British Columbia and Alberta, but it is being raised in wild-life sanctuaries in Saskatchewan and Manitoba as well.

Another example of a species that came close to extinction is the bison, the animal that most of us call the "buffalo". The original herds of these animals were estimated to be in the neighbourhood of 50 million, but by 1889 the total wild population had been reduced to a little over 600. At the lowest the herd in the Canadian north shrank to about 250. In 1893 the killing of the buffalo in the north was made illegal, and in 1922 the area where the herd was to be found was made into the 17,300-square-mile Wood Buffalo National Park, a park nearly as big as Nova Scotia, and the largest park on the continent. The herd has now increased to about 17,000 and some of them have moved beyond the borders of the park and onto the flats south of Great Slave Lake.

Although the settlement of the country had an adverse effect on many species of wild-life, as the above examples indicate, it often had quite the opposite effect, favouring the

The wild turkey, once abundant in North America, is now almost extinct.

Ontario Department of Lands and Forests

rapid expansion of various forms of life that were previously inconspicuous or completely unknown in this country.

The clearing and cultivating of the land had many far-reaching effects. Some animals, such as the varying hare, retreated farther north, but the cotton-tail rabbit and birds of the open spaces such as the meadow lark and the bobolink extended their range as clearings were made.

With the settlement of the land many harmful weeds were introduced, and before long insect pests such as the cabbage butterfly, the corn borer, and the potato beetle found their way to the cultivated fields, while rats and mice made themselves at home in the barns and houses. To keep these invaders in check we continue to spend many millions of dollars annually and there is no likelihood that we will ever be able to eliminate them completely.

Many of our most troublesome pests were deliberately introduced by well-meaning people who could not foresee how they would react to their new environment. In the year 1850 house sparrows were released in several towns in the United States and Canada, and others were released a few years later. At first great efforts were made to help these birds become naturalized; bird houses were erected for them and they were protected by law. Later it was found that grain and not insects was their favourite diet, but it was too late then to stop their rapid multiplication and continent-wide spread.

In 1890 eighty European starlings were liberated in Central Park, New York City, and a year later forty more were released at the same place. From these 120 birds originated all the millions of starlings now found on this continent. In Europe, the starling is regarded as a beneficial bird, or, at worst, one that fits inconspicuously into the scheme of things. Here, where it is free from the restraints of its normal habitat, it has multiplied to an extraordinary degree and has become a serious competitor of our native birds. Thousands of starlings congregate in shade trees in cities and are a great nuisance to people who live near by. Starlings are also a serious menace

The extinction of the whooping crane has, so far, been forestalled by the efforts of the conservation authorities and people interested in conservation of wild-life.

Allan D. Cruikshank from National Audubon Society

to the fruit-growing industry because of the extensive damage they do to small fruits such as cherries and grapes. Recently they were suspected of causing an air disaster when numbers of the dead birds were found in the turbo-prop engines of the wrecked plane. Attempts to control the starling have not had much success so far, and we can only hope that disease or some other natural cause will bring about a reduction in their numbers.

The balance of nature has been disturbed, not only on land and in the air, but also in the water. The smelt that are now so thoroughly established in the Great Lakes originated from a quantity of eggs brought from New England in 1912. The eggs were deposited in Crystal Lake near Frankfort in northern Michigan. For a while it was thought that the planting had been unsuccessful, but some years after the experiment had been forgotten, smelt showed up at the original site in great numbers, and not long afterwards they were found in Lake Michigan near the outlet from Crystal Lake. The first record for Lake Michigan was in 1923, and each year thereafter reports kept coming in from points farther and farther away. By 1932 smelt were well established throughout Lake Huron and Lake Michigan, and were spreading gradually to the other Great Lakes. They reached a peak of abundance in the early 1940s, dwindled for a time to relatively small numbers, and then surged up again to a very great population.

Spawning takes place in late March or April. At this time the mature fish develop a desire to resist a current, and crowd into the streams, where they are easily taken by scoop nets and dip nets. Since the food of the adult smelt is young fish and insect larvae, they are bound to have a very serious effect on the native fish both as competitors and as enemies.

Probably the greatest damage to the fisheries of the Great Lakes has been caused by that repulsive, jawless creature, the sea lamprey. Lake Ontario was once an arm of the sea, and many scientists think that the lamprey was one of the original inhabitants of this lake. Whether or not it was present in the

The sea lamprey is a recent arrival in the upper Great Lakes.
National Film Board

remote past, it certainly had access to Lake Ontario from 1825 on, for in that year canals went into operation, by-passing the rapids and permitting the passage of ships from Montreal to Kingston.

For a while there was no possibility of the lamprey's penetrating farther than Lake Ontario, but with the opening of the Welland Ship Canal in 1829 to by-pass Niagara Falls, the way was open for the loathsome parasites to reach the upper lakes. Nevertheless, they were very slow to find their way through the canal, and it was almost a century later (1920) before an occasional one was taken at the eastern end of Lake Erie. Conditions in Lake Erie were apparently not very attractive to them either for feeding or for spawning, and it was not until the early 1930s that they extended their range to the cooler waters and tributary streams of Lake Huron. Here they found conditions more to their liking, and it took them only four years to spread through Lake Huron and enter Lake Michigan, where they again spread rapidly. Commercial fishing in these lakes fell off alarmingly, particularly for lake trout, the most valuable of the fishery assets. Lake sturgeon almost vanished and finally the lampreys turned their attention to pickerel, whitefish, herring, and suckers. With the reduction of the larger carnivorous fish, smaller fish increased in numbers, but these were of little value to the fishermen, whose unused boats and gear rotted beside deserted wharves. When lampreys reached their peak in these lakes, many of the beaches became unusable because of the dead fish washed up by the waves. The herring gulls profited by this situation, and with plenty of food available their numbers rapidly increased. An increase in one species inevitably affects other forms of life, and as we trace the consequences further and further we begin to see how a single disturbance in the balance of nature spreads in ever-widening circles like ripples from a stone dropped into a quiet pool.

The first record of lampreys in Lake Superior was obtained in 1946. All attempts to prevent them from passing through

the locks at Sault Ste. Marie failed, and gradually the commercial fisheries of Lake Superior suffered the same fate as those of the other Great Lakes.

Several attempts are being made to control the lamprey. One of these is the use of electric fences across the mouths of the streams that they enter to spawn. However, it is very difficult to make sure that *every* stream they might use is guarded in this way. It is also unlikely that results from this method will be detected for a considerable time, since the streams already contain great numbers of larvae from previous spawnings. Recently a chemical has been discovered that is acutely poisonous to the larvae without seriously affecting other aquatic life. This substance, given the trade name of "Dowlap", has had very encouraging results, and it may yet be possible to undo some of the harm resulting from the spread of the lamprey, and restore, at least partially, the once-valuable fisheries of the Great Lakes.

QUESTIONS

1. Describe the appearance and habits of the passenger pigeon. What were some of the factors that brought about its extinction? When did the last passenger pigeon die?
2. What is the date of the last official record of a wild turkey in Canada? What were the main causes of its disappearance?
3. Describe the appearance and migratory habits of the whooping crane. Approximately how many of them are known to exist at the present time? How were they reduced to such small numbers?
4. Find pictures of the trumpeter swan and read a description of its habits and life history. Why was it hunted almost to extinction?
5. What is the correct name of the North American "buffalo"? Describe the size and range of the original herds. Why were they slaughtered in such great numbers? Indicate on a map the location of Wood Buffalo National Park.
6. Make a list of various forms of life that increased in numbers as a result of the clearing and settling of the land.
7. Describe the history of the house sparrow and the starling in North America. Why were they introduced and what were the consequences?
8. How did the smelt become established in the Great Lakes? Discuss the effect of their presence on the economy of the Great Lakes fisheries.
9. Look up information on the life history of the sea lamprey. How did lampreys gain access to Lake Erie? How long did it take them to become established? When were lampreys first noticed (a) in Lake Huron, (b) in Lake Superior?
10. Discuss the lamprey under the following headings: (a) its effect on the fisheries of the Great Lakes; (b) present methods being used to combat it.

PART V: MAN AND NATURE

28 The Buffalo

THE BUFFALO HUNT (1827)*

In October the herds of bison began their leisurely march towards the wooded section of the country, near the foothills of the Rockies. And what a sight it was to see a drove of thousands moving majestically a few steps, then pausing for a mouthful or two of grass – another few paces, another mouthful, and so on – always travelling in the one direction. When spring came in the following year they would turn tail on the wooded areas and make again for the open prairie.

The joys of the hunt! Soon I was to learn its routine. A sort of rhythm pervaded it. The vast plains teemed with herds of *les animaux*, as my half-breed friends called them, or as the Crees named them, *Mus-toos-wuk*. The captain for the day would give the order for a run. You'd saddle your mount, parade out in a slow canter till a convenient mound or hill hid the hunters from their quarry, dismount to offer a short prayer,

* This excerpt, and "The Stampede", are reprinted by permission of the author from *John Kerr* by Constance Kerr Sissons, published by the Oxford University Press, Toronto.

remount and await the captain's word to "let loose". Sure then it was every man for himself – a quick rush on the unsuspecting herd, each hunter singling out his particular animal.

Crack! Crack! went the guns; or, if Indians were in the group, you'd hear the twang of bow-string and the hiss of the arrow as it sped to and found its mark. Now the grunt of the buffalo as he toppled headlong! (If his wound was not mortal, care was needed, for a wounded buffalo was a dangerous animal.) Then on after another and another till you had enough or your horse was tired.

Then back you would ride to your kill, dismount, spread the fallen monarch. Out would come the razor-sharp knife and in an incredibly short time the beast would be skinned, cut up, and ready for the carts that had been driven on the field by the women-folk. And back to camp you'd go.

There were dangers, for wounded animals might turn on you or your horse step into a badger hole and tumble you out of your little running-saddle. But the hunter is blind to danger in the excitement of the chase.

THE STAMPEDE

A very slight cause would set a whole herd of the animals on the stampede – a fearsome sight – turning the whole landscape, in the twinkling of an eye, into an undulating sea of backs. The noise of hoofs cracking, of horns crashing, would soon be lost in a thunderous pounding of feet. In the summer months the sound was a hollow rumble; in the fall of the year, when the ground was frozen, it had more of a staccato quality. Woe befell any living thing in the path of a stampeding herd of seventy-five or one hundred thousand buffaloes! Darkness seemed to increase the strange fear that possessed the animals in their mad panics, an uncanny fear that would repay a present-day student of mass psychology. On they would go, lunging and plunging till, through sheer exhaustion, they

would come to a standstill, panting, their tongues lolling out, flanks heaving, eyes wild and bloodshot.

TOUCHWOOD HILLS*

This region bears the name of the Touchwood Hills. Around it, far into endless space, stretch immense plains of bare and scanty vegetation, plains seared with the tracks of countless buffalo which, until a few years ago, were wont to roam in vast herds between the Assiniboine and Saskatchewan. Upon whatever side the eye turns when crossing these great expanses, the same wrecks of the monarch of the prairie lie thickly strewn over the surface. Hundreds of thousands of skeletons dot the short scant grass; and when fire has laid barer still the level surface, the bleached ribs and skulls of long-killed bison whiten far and near the dark-burnt prairie. There is something unspeakably melancholy in the aspect of this portion of the North-west. From one of the westward

* Reprinted from *The Great Lone Land* by W. F. Butler, published by the Musson Book Co. Ltd., Toronto.

This buffalo, in Banff National Park, is one of a few thousand survivors of the vast herds that once roamed the plains of North America.

Canadian Wildlife Service

jutting spurs of the Touchwood Hills the eye sees far away over an immense plain; the sun goes down, and as it sinks upon the earth the straight line of the horizon becomes visible for a moment across its blood-red disc, but so distant, so far away, that it seems dreamlike in its immensity. There is not a sound in the air or on the earth; on every side lie spread the relics of the great fight waged by man against the brute creation. All is silent and deserted – the Indian and the buffalo gone, the settler not yet come.

THE BUFFALO-BONE BUSINESS*

The buffalo-bone business, mentioned earlier as the first cash crop of many settlers, spread with railways and settlement and was of benefit to both. Regina, Saskatoon, Moose Jaw, Medicine Hat, Swift Current, and Calgary were among the important shipping points. Most of the bones went to the United States, where they were used for bleaching sugar, manufacturing fertilizer, and in some cases for making household articles.

As new railways were built, new supplies of bones were obtainable. The area around Saskatoon provided a bountiful crop for the bone harvesters after the rails were laid in 1890, and the new town witnessed the departure of many carloads of the remains in the peak years of 1891 and 1892. The "bone trail" that entered the city from the south-west became a pioneer highway. Now and again freight cars ran short and the bones had to be piled along the tracks. Each pile was the size and shape of a box-car. Skulls formed the outside walls and the smaller bones were thrown into the centre. Oldtimers recalled that the piles of bones waiting shipment at Saskatoon sometimes extended from 23rd Street to a point on the river close to the present railway bridge.

Mrs. Grace Fletcher, James Leslie, and R. W. Dalmage,

* Reprinted from *Between the Red and the Rockies* by Grant MacEwan, by permission of the University of Toronto Press.

who operated stores in pioneer Saskatoon, handled most of the bones at that point. But others were in the business too. The diary of W. H. Duncan, who opened a store there in 1890, showed four carloads shipped on the 6th of September, 1890, seven cars on the 9th, four cars on the 10th, and six cars on the 17th of that month.

All went well until the financial panic in 1893, when the bone boom burst. By that time Leslie was handling nearly all the bone business at Saskatoon, shipping to the Northwestern Fertilizer Company in Chicago. The company got into deep water financially and wired Leslie to stop his shipments. But telegrams did not always reach their destination in those years and the bones kept coming. At one stage thirty-five carloads were being held in Chicago with no prospect of their disposal. However, after a costly delay, the market improved and Leslie sold his bones.

Many of the bones delivered at Saskatoon were gathered by French half-breeds from Fish Creek and Batoche. Some were gathered by Sioux Indians from the reservation near Dundurn. The half-breed and Indian pickers usually accepted goods in exchange for bones, and very little cash changed hands. In spite of abundant bones for the picking and a good market for them, the Métis usually contrived to finish the season in debt. W. K. Fletcher wrote to me in 1936 that he recalled Edouard Dumont, brother of the celebrated Gabriel, saying to his mother, Mrs. Grace Fletcher, at the end of the season, "Madam, I owe you forty-five dollars; I send you cattle." The reply would be, "That's fine; send them in the spring." In the following spring a number of cows and calves would arrive to balance the account and everybody would be satisfied.

It was the practice of some of the bone gatherers to set fire to the prairie grass in early spring or late summer, so that the white bones might be clearly exposed to view. "In the spring of 1888," wrote James Leslie to me in 1936, "I went by trail to Moose Jaw. The country south of Beaver Creek had been burned and buffalo bones showed white; the whole country

looked like a very stony Ontario summerfallow."

Another pioneer told of a homesteader working single-handed and gathering three carloads of bones in three weeks. It was his first harvest and a very good one. Basket racks, twelve or fourteen feet long and three feet high, were employed for gathering and the horses which hauled them were of the cayuse or Indian pony type, small and tough. A ton would be an average load. When picking was conducted some distance from a railroad, the pickers with their carts or wagons might travel as a caravan. Such a wagon train might extend, when in motion, for a mile or more on the trail, and the squealing of its wheels could be heard for several miles. Positions at or near the front of the procession were competed for. The better horses and better men won leading places while the slower horses and indifferent drivers sweated amid the dust at the rear.

At first picking was confined to the districts adjacent to the railroads but when these were cleared of bones, the gangs moved farther afield, perhaps fifty to a hundred miles. The district around the present Rosetown was especially productive and so was the Blackstrap Coulee, east and south of Dundurn. At least a hundred cars of bones were gathered up at Hanley. Pickers working in rough country farther south and west found coulees and cut-banks with accumulations of bones totalling up to forty or fifty tons at one place.

James Leslie alone sent 750 carloads of buffalo bones out of Saskatoon and estimated that the total shipment from that point was between 3,000 and 3,500 carloads. Loaded cars carried roughly twenty tons and [included] about 250 skulls. If each carload contained the bones of 250 animals, the shipments from Saskatoon alone represented something over 750,000 buffalo. One can only speculate about the quantity of bones which went from all of Western Canada.

Bones delivered at the railroad netted a credit of six to eight dollars a ton for the pickers and more than one homesteader obtained his first plough or first barbed wire or first lumber

with "bone money". It is surprising and a little disappointing that some Saskatchewan or Alberta town didn't take the meaningful name of "Buffalo Bones". It would have been preferable to some of the imported and unwestern names which were adopted.

PART V: MAN AND NATURE

29 Human Resources

When we hear the word "resources" we usually think of forests, fields, mines, and water-ways. However, we should not forget that the wealth of these resources is *potential,* and it would remain forever unknown and unused if it were not for man's ability to recognize it, and his inventiveness in devising ways to extract and utilize it. It is apparent, therefore, that the greatest resource of all is the resource of human intelligence, for it is this that makes the other resources available and determines how they will be used. In fact it would not be an exaggeration to say that the most important resources of any country are the character and intelligence of its people. It follows, therefore, that if we are concerned about the conservation of our natural resources, we should be concerned even more about the conservation and development of our human resources.

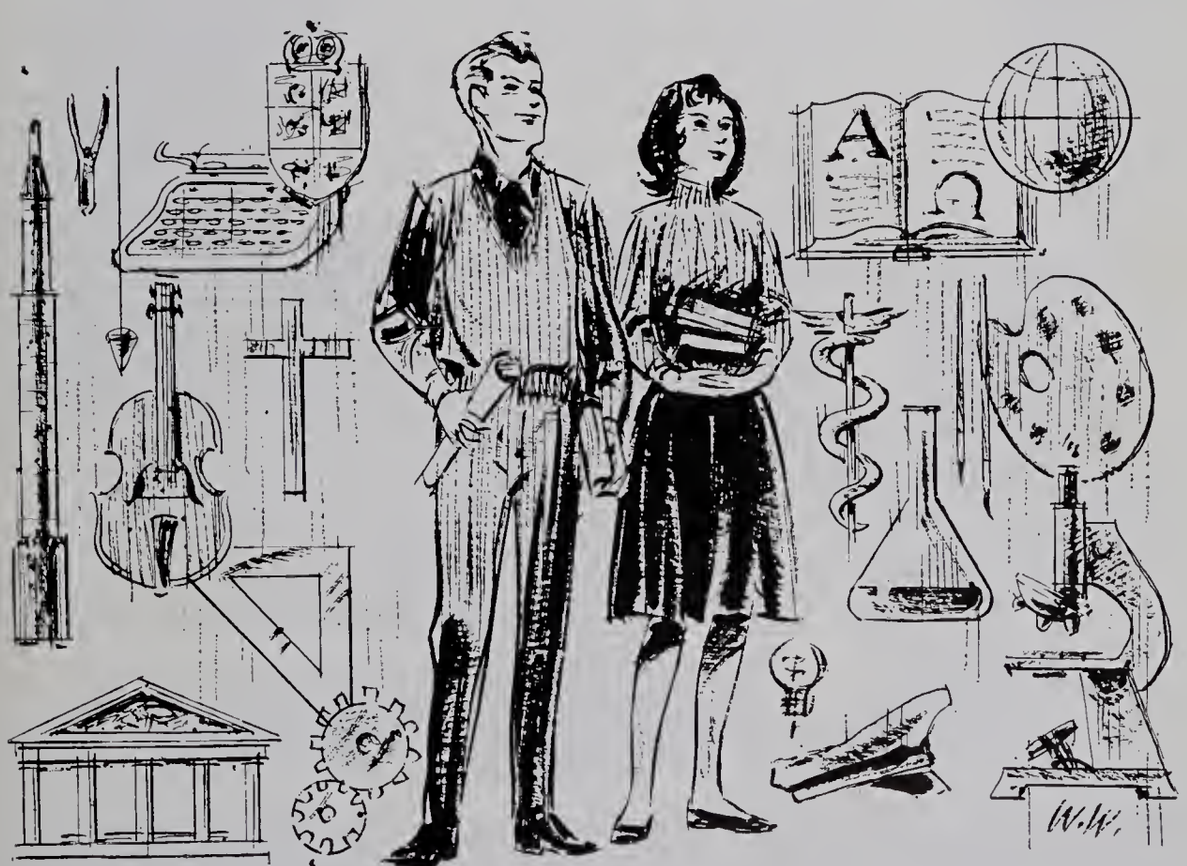
One of the most obvious ways of conserving human resources is to foster good health and physical fitness. Since the beginning of the present century medical science has brought

many diseases so completely under control that they are no longer a serious menace to human life or health.

Great advances have also been made in the treatment of crippling disabilities that were formerly considered incurable. Diseases such as tuberculosis and poliomyelitis, which often led to permanent disability, are now being made to yield to new methods of control and rehabilitation. Excellent progress has been made in the care of young handicapped children by the combined efforts of government agencies and crippled-children's organizations.

While we have conquered many of the terrible diseases that used to scourge mankind, another danger has come to menace us – the greatly increased danger of accidents. In the world today accidents cause more deaths than any single disease except cancer and heart disease.

Although they are the third ranking cause of death among the population at large, they are the *leading* cause of death for all young people between the ages of five and nineteen, and



One of the most important resources of our country is its young people.

National Health and Welfare, Ottawa

With the aid of rehabilitation equipment and services, this young polio victim can hope to achieve her maximum potential recovery.

for males between the ages of twenty and forty-four. There are more fatalities in automobile accidents than in accidents of any other kind. Fatal accidents in the home number more than those in industry, and the number of deaths from drowning and fires is almost equal to the number of deaths in industry.

The accident toll of our highways is increasing at an alarming rate as each year sets a new record of deaths, injuries, and property damage. At present we are killing about 3,000 people a year on our highways, not to mention the vastly greater number injured and incapacitated. In fact the number of people injured on the roads each year in Canada is greater than the total number of those wounded in any war in which Canada was engaged!

One of the causes of automobile accidents is excessive speed under conditions that are far from ideal. At 50 miles per hour and under normal conditions, about 240 feet is required to stop, and even at 30 miles per hour nearly 100 feet is required. Considerably more distance is needed if the driver is impaired or has a slow reaction time. It often appears that drivers in residential areas and in the vicinity of schools are oblivious to these facts, or else they simply take the irresponsible attitude that pedestrians had better keep out of their way.

Of course excessive speed is only one aspect of carelessness, which together with selfishness and impatience is probably the greatest cause of highway accidents. Drunken driving is one of the most intolerable offences a person can commit, and one for which very serious penalties should be exacted. The behaviour of teen-age boys who show off by driving recklessly should be just as intolerable. Boys could be discouraged from this practice if the girl friends they are hoping to impress made it clear that they regard them as dangerous fools rather than heroes.

The prevention of highway accidents is largely a matter of overcoming our apathy and developing a more mature attitude towards our responsibilities both as drivers and as pedestrians.

We will also have to insist upon stricter law enforcement, more rigid driving tests repeated periodically, and complete removal from the highways of dangerous cars and dangerous drivers.

Accidents in the home are more numerous than automobile accidents, although there are fewer fatalities. Fire is a frequent cause of death and injury, and the greatest number of fire accidents occur in and around the home. The main cause again is carelessness in one form or another, children playing with matches, adults smoking in bed, or using coal oil or gasoline to start a fire in the stove. Over-heated stove-pipes and over-taxed electrical wiring are also frequent causes of fires.

Another danger in the home is that of poisoning. Many common household substances such as lye, detergents, bleaches, dry-cleaning fluids, and iodine are deadly poisons if taken internally, and many common types of pills or medicines could be fatal if taken in large doses. Such substances should never be left within reach of children, and no one should ever take pills or medicine without turning on the light and carefully reading the label on the bottle. Poisonous substances or disinfectants should never be placed on a shelf where foods are stored, first, because they may contaminate the food, and secondly, because many dangerous poisons are easily mistaken for flour or baking soda.

A form of accident that is all too prevalent is the type associated with water sports. Whatever the cause, most water accidents should be avoided by the exercise of a little more care and common sense.

With our cars, our boats, our fire-arms, our electrical devices, our fires, and our poisons, we are in far greater danger of accident than any previous generation. In this environment we must endeavour to make safety a habit, and this can best be done through the medium of education.

While sickness and accidents cause the most obvious waste of human resources, there are many factors that tend to reduce

the energy and effectiveness of the individual. One of these is alcoholism, a chronic condition involving habitual excessive drinking. It has been estimated that problem drinkers in Canada cost their employers one million dollars every working day, not only as a result of absenteeism, but also because of mistakes, accidents, slowed production, wasted materials, or offended customers. The effect of alcoholism on crime and social problems is also very great, and much of the misery encountered by welfare agencies and social workers is the result of this condition.

Science has not yet isolated any marked physical difference between those drinkers who become alcoholics and those who do not. The process is usually so gradual that the victim does not realize until too late that he can no longer stop once he begins to drink. Whatever method of treatment is attempted, it is usually a long, slow process and involves great determination on the part of the alcoholic himself.

In spite of the great advances in modern medicine, mental illness remains one of the most difficult of our health problems. Nearly 100 million dollars are spent every year on mental hospitals, and many more millions are spent on clinics, schools for the retarded, treatments in the home, and the training of doctors and nurses. It may be that the increased number of cases under treatment is related to the increase of population and a changing attitude toward the treatment of such cases, but there is also an indication that it is due in part at least to the complexities and pressures of modern living. Whatever the cause, it is one of the greatest problems society has to face, and one of the most tragic examples of wasted human resources.

Another tragic waste of human resources is the result of crime and the necessity of keeping a considerable number of people confined in jails and penitentiaries.

In our study of the subject so far, we have dealt with situations where the waste of human life is clearly apparent. There are, however, many less obvious ways in which human re-

sources are wasted. A person may be in good health and have no harmful or criminal tendencies, yet he may spend most of his life in the pursuit of useless or trivial things. Human resources are wasted when a person is employed at work for which he is not suited or when a talented person is denied the opportunity to use his talents.

There is a great waste of human resources when young people of good ability drop out of school through lack of interest or incentive. Of course, there are good reasons why some pupils may not go as far in school as others, but the tragic waste occurs when pupils who have the ability fail to remain at school, or if they remain, content themselves with mere passing marks when they are quite capable of obtaining high honours. Education is much more than training for a job. Nevertheless, there is an important relationship between education and earning-power. Statistics show that the man whose education ends with elementary school will make on the average $178,000 during the forty or so years that he is working. The high-school graduate will earn in the same time $243,000, and the university graduate $347,000. All of these figures will probably be increased as wages increase.

Automation and the increased use of machines is making it possible for us to produce all the goods we need with less and less expenditure of human energy. This means that the work-week will probably become shorter, perhaps thirty-two hours or even twenty-five hours, with a corresponding increase in leisure time. If this leisure time is not used to good advantage, it might not only be a waste of human resources, it could actually have a demoralizing effect on human character. We should plan to use our leisure time constructively and not simply in idleness, self-indulgence, and passive entertainment.

QUESTIONS

1. Why do we say that human resources are more important than any other kind?
2. Make a list of diseases that caused great loss of life a hundred years ago and that are now almost completely under control.
3. What is the leading cause of death for young people between the ages of 5 and 19?
4. How would you define an "accident"? Where do most accidents occur? Where do most *fatal* accidents occur?
5. What are the main causes of highway accidents? What steps do you think should be taken to reduce highway accidents? Discuss (a) defensive driving, (b) the use of safety belts.
6. Make a list of precautions that should be taken to prevent accidents in the home due to (a) falls, (b) electric shock, (c) fire, (d) poisoning.
7. What precautions should be taken when (a) hunting, (b) skiing, (c) swimming, (d) boating?
8. What is alcoholism? How does it affect (a) the person himself, (b) his employer, (c) his family, (d) society in general?
9. Discuss the subject of mental illness under the following headings: (a) expense, (b) loss of human resources, (c) possible causes and cures.
10. Discuss the subject of crime under the following headings: (a) prevention, (b) detection, (c) punishment, (d) rehabilitation. Name some organizations concerned with the rehabilitation of prisoners after they are released.
11. Why is it important to make the best possible use of our educational opportunities?
12. Give specific examples of the proper and improper use of leisure time.

PART V: MAN AND NATURE

30 Man and His Environment

The ancient Greeks were very close to the truth in their belief that the four basic "elements" were fire, earth, air, and water. Today we do not call them elements, and we exclude fire, which is not a substance but a form of energy. The remaining three, however, are still recognized as the fundamental components of our planet and all the living things that exist upon it. Any harm, therefore, that comes to the soil, the water, or the atmosphere is bound to make conditions more difficult for all forms of life on the globe, including human life.

Most of us have come to realize that the word "inexhaustible" should never be used in relation to our forests, our wildlife, or our minerals, but there still seems to be a general impression that the great fundamentals – earth, air, and water – will never fail us and that it is unnecessary for us to be concerned about depleting or harming them. There is still relatively little concern about contaminating the land by the improper disposal of sewage or garbage, or the use of chemical sprays. There is still too little concern about releasing smoke,

fumes, and gases into the atmosphere, and it is apparent that many people still believe that the best way to dispose of any form of waste or trash is to deposit it in the nearest lake or stream (see Chapter 15). We have done these things in the past and have survived because of our relatively small numbers, but as populations increase and industries expand, environmental pollution is bound to emerge as one of the greatest problems we will have to solve.

We know less about soil pollution than we do about the other forms, but there is no doubt that it is an important link in the chain of environmental pollution. Like a giant blotter, soil soaks up pollution from garbage and sewage and also pollutants that are washed down from the atmosphere by rain or snow. Some of these dangerous substances may enter the roots of growing plants or find their way to the sources of water supply.

This refuse floating on a stream is one example of wanton pollution of our natural resources.
"Civic Administration", Toronto

"Civic Administration", Toronto

Thoughtless scattering of garbage along highways is another evidence of abuse of natural resources.

The most widely used method of garbage disposal is still the garbage dump. These open dumps often cover a considerable area, and from them pollution soaks into the surrounding land and may even spread to wells or other water sources. They are also breeding-grounds for rats which usually harbour disease. If burning is used as a method of disposal, the air is polluted with foul-smelling smoke.

Much better than the open garbage dump is the method of disposal known as sanitary land-fill. This requires that the garbage be spread in the bottom of a depression and then covered with about 18 inches of compacted earth, then another layer of garbage and another layer of earth until the depression is filled. Finally the surface may be seeded or sodded, and in this way a swampy, unsightly piece of land may be transformed into a park or other valuable property. Many of the scenic parks in and around our large cities have been formed in this way, and there are numerous instances of the checking of erosion and the saving of valuable property by the well-planned use of sanitary land-fill. Metropolitan Toronto is now considering a plan to create an eighteen-hundred-acre shoreline park on top of thirty-six million tons of industrial and domestic refuse. This project would require twenty years to complete and would be one of the largest sanitary disposal and land-fill operations in North America. In all garbage-dumping and land-fill operations the selection of a site and the drainage from the site are of the utmost importance from the point of view of public health. In the case of land-fill operations, however, careful planning and proper techniques would eliminate any danger of contamination.

In some countries the garbage is carefully sorted and all the organic waste is composted by spraying it with a bacterial culture so that it soon decomposes into an excellent granular topsoil. Municipalities in Canada rarely do this, but the same result could be obtained if every home-owner who has a garden or even a lawn would maintain a small compost pile and use the household organic wastes to enrich the soil.

There are many ways of treating sewage before discharging it into lakes or water-courses, but it will be some time yet before every Canadian municipality has some form of sewage treatment. In the meantime there are many instances of the discharging of raw sewage directly into rivers and lakes. Many towns, villages, and suburban areas as well as farms, resorts, and outlying hospitals and industries depend upon septic tanks

to dispose of sewage. Such installations function satisfactorily if conditions are suitable for natural bacterial action, but there are many harmful chemicals and detergents that will destroy the useful bacteria. To avoid inhibiting the bacterial action, these harmful substances have to be drained into a separate cesspool, and here also there is danger of soil and water pollution unless the cesspool is very carefully designed and constructed. If a septic tank leaks, or if the bacterial action is not functioning efficiently, raw sewage may seep into the soil and find its way to neighbouring wells or springs. If seepage is suspected it may be investigated by the use of a dye called fluorescein. A teaspoonful of this dye is flushed down the toilet, and if any of the colour is detected in the well water it shows that there is contamination from the septic tank.

Solid waste products from industry sometimes cause pollution of the land. Slag and tailings from mining and smelting operations, and deposits of sawdust, chips, or bark from wood-using industries are examples of this. Careful planning can usually prevent such deposits from causing serious harm to the surrounding area, but the location of the deposits in relation to run-off is of the utmost importance. Sometimes arsenic, cyanide, or other poisons may be present, and these may be leached into the soil or washed into streams and carried to considerable distances. The improper use of fertilizers may have a bad effect on the soil, and run-off from heavily fertilized land may have undesirable effects on the neighbouring water-courses.

In our fight against insects, weeds, and plant diseases we sometimes use remedies that may in the long run prove to be worse than the conditions they are intended to correct. Paris green, used to control potato beetles, and lead arsenate, used on fruit, tobacco, and other crops, both contain arsenic. Over a period of time the arsenic contained in these substances is bound to accumulate in the soil and may become associated with the plants either externally or internally. Another difficulty with chemical sprays and powders is that the

insects gradually develop immunity, and as time goes on larger and larger doses must be used. In some cases insects become so resistant to a certain poison that a new one must be developed, and eventually they become immune to it also.

The insecticide D.D.T. was credited with spectacular results when it first appeared. During the Second World War it effectively controlled mosquitoes, fleas, and lice and thus prevented the spread of malaria, plague, and typhus. It was used with considerable success in massive aerial sprays for the control of the spruce budworm and other forest pests, but as time went on it gradually became less effective and it was soon discovered that it had a number of undesirable side effects. Valuable game birds as well as insectivores and song-birds were seriously affected by it. Although in some cases birds did not appear to be directly affected, it was found that a high mortality developed among their offspring. Newer insecticides have since been developed, but the same defects are found in them also. Another undesirable effect of insecticides is the destruction of useful insects, such as bees and the parasitic insects that help to destroy the harmful ones.

Many townships have adopted the practice of spraying the ditches and roadsides with weed-killer and brush-killer. This usually results in the destruction of food and cover for what little wild-life remains, and leaves an unsightly tangle of dead leaves and stems. No doubt a certain amount of clearing is necessary along the roadsides, but it is unlikely that the indiscriminate spraying of wayside plants is the best solution. Useful and attractive shrubs such as viburnum, dogwood, hazelnut, and honeysuckle are sacrificed along with the weeds and brush, and nesting song-birds and insectivorous birds are destroyed. It is very unlikely that those who authorize such large-scale operations have any idea of what becomes of the spray when it enters the ditches. Does it drain into a stream or fishpond? Could it spread over a field after a rain-storm, or could it find its way into water that people or cattle drink?

Not nearly enough is known about the effect of poisonous

sprays, whether insecticides or herbicides, and a long period of experimenting is required to find out the effect of each poison on each species of plant and animal. The problem is further complicated by the fact that as soon as one series of experiments is completed a new poison comes on the market and the whole process has to begin all over again. For this reason many biologists and conservationists believe that instead of relying on the wholesale use of poisons we should use to better advantage the other means of control at our disposal. Such methods would include good farming and forestry practices, protecting insectivorous birds, using insect parasites and diseases, using synthetic mothproof fibres, and using metal and concrete to prevent the inroads of termites.

The third great segment of our environment that we must endeavour to protect from pollution is the atmosphere. Every day we inhale between twenty-five and fifty pounds of air, while we ingest only two to four pounds of food and about the same weight of water. It is clear, therefore, that pollution in the atmosphere affects us very intimately, and that it is a form of pollution from which it is very difficult to escape.

A good deal of atmospheric pollution comes from individual heating units and the operation of cars and trucks. Industries also pollute the air with smoke and fumes, and some pollution may originate from the burning of refuse or from municipal incinerators. In recent years we have also become concerned about radioactive fall-out resulting from atomic explosions.

Apart from fall-out, scientists divide aerial pollutants into two classes, *aerosols*, and *gases*. Aerosols are minute solid particles or liquid droplets suspended in the atmosphere. They include smoke fumes, dust, and mist. Gases, on the other hand, are not made up of visible particles, but they may be very irritating or dangerously poisonous.

Some of the ill effects of atmospheric pollution are:

(1) Impaired health because of damage to the lungs and respiratory organs. Lung cancer, chronic bronchitis, and

This photograph illustrates the atmospheric pollution in a modern city, much of which could be prevented.
Canada Wide

asthma are some of the diseases believed to be either caused or aggravated by polluted air.

(2) Eye irritation and infection.

(3) Loss of sunlight and its disinfecting action on the air.

(4) Reduced visibility, resulting in traffic tie-ups and accidents.

(5) Soiling of clothing, laundry, and the windows and walls of buildings.

(6) Corrosion of buildings and metals and the destruction of plants by acid-forming gases such as nitrogen dioxide and sulphur dioxide.

(7) Poisoning by gases such as carbon monoxide and nitrogen dioxide.

Although something is known about the ill effects of each pollutant taken by itself, we still know very little about the complications that may arise as a result of their reactions with one another. It is well known that humidity aggravates the danger and that one of the worst conditions is that combination of smoke and fog which is appropriately called "smog".

There are many ways by which atmospheric pollution can be reduced. Industries are aware of the pollution that will be caused by their operations, and the prevention of pollution should be included in their original plans and estimates. Since pollution of the air is usually a sign of waste, money spent on pollution control often turns out to be a good financial investment. There is no doubt that if we are sufficiently concerned we can find ways of reducing considerably the quantity of dangerous pollutants that are constantly being discharged to the atmosphere from our homes, factories, and machines.

Polluted air is no respecter of municipal or international boundaries, and there are a number of problems that can be solved only on a regional or international basis. Chief among these is the problem of radioactive fall-out.

The explosion of nuclear weapons, like the opening of Pandora's box, released upon the world a loathsome assortment of radioactive particles. When an atomic bomb is ex-

ploded, clouds of radioactive particles are hurled high into the atmosphere and may eventually be distributed almost anywhere on earth. These particles will gradually be brought down by rain or snow and will enter into the soil and water. From the water and soil they follow the food chain through plants and animals to ourselves.

Of the fall-out particles, strontium 90 is one of the most malignant. It is chemically similar to calcium, and like calcium it enters into the formation of bone. Here it accumulates, and by irradiation of the bone marrow (where blood cells are manufactured) it may cause leukaemia, or cancer of the bone itself. The effect would naturally be more serious in growing children than in adults, where replacement of bone tissue is comparatively slow. Another radioactive substance born of the atomic bomb is caesium 137. Unlike strontium 90, it does not become localized in any one tissue but is fairly evenly distributed throughout the body.

There is a good deal of conflicting opinion about the dangers of radioactive fall-out and no one seems to know with certainty how much is safe, permissible, or tolerable. One thing, however, is certain, and that is that substances as malignant as these are undesirable in any quantity no matter how small that quantity may be.

This last example of environmental pollution illustrates how great a difference exists between man's scientific ingenuity and his ability to control the forces that his ingenuity creates. The great challenge of the future is to narrow this gap and to learn how to apply our technical skill to the improvement of our environment and the conservation and proper management of our resources.

QUESTIONS

1. How do pollutants from the atmosphere reach the soil? How might they finally enter the human body?
2. Describe and compare two methods of disposing of garbage. Find out from a book on gardening how to construct and maintain a compost pile. What are the advantages of having one?
3. What precautions should be taken to keep a septic tank operating efficiently? How could you test for suspected seepage to a well?
4. Make a list of solid waste products discharged by industries. Discuss the possible ill effects of these deposits and how such ill effects might be prevented.
5. What are some of the difficulties encountered in the use of insecticides and weed killers? D.D.T. has been found in samples of milk, and even in fish caught off the Atlantic coast. Explain how this might have happened.
6. Is there a danger of obtaining arsenic or other poison from food or tobacco? Explain.
7. What are the main sources of atmospheric pollution? Distinguish between aerosols and gases. What is "smog"?
8. Make a list of ill effects caused by pollution of the air.
9. Describe a number of methods that might be used to reduce air pollution.
10. Write a brief note describing the origin, distribution, and possible effects of radioactive fall-out.

Further Reading

I: THE EARTH

BERTON, PIERRE. *The Klondike.* McClelland and Stewart, Ltd.

CANADA, DEPARTMENT OF MINES AND TECHNICAL SURVEYS. *Minerals, Canada, and the World.* Ottawa: Queen's Printer.

ERNST AND DE VRIES. *Atlas of the Universe.* Thomas Nelson & Sons (Canada), Ltd.

EVANS, W. W. *Petroleum.* Clarke, Irwin & Co., Ltd.

GAMOW, GEORGE. *The Creation of the Universe.* The Macmillan Co. of Canada, Ltd.

IMPERIAL OIL CO. *The Oil Seekers, The Oil Refiners, The Oil Movers.* (These booklets are available from the Imperial Oil Co., 150 Laird Drive, Toronto.)

KING, ALAN. *The Exciting Story of Nickel.* International Nickel Co. of Canada, Ltd. (Available from the publishers, 55 Yonge Street, Toronto.)

LANGFORD, G. B. *Out of the Earth.* University of Toronto Press.

"LIFE", THE EDITORS OF, AND LINCOLN BARNETT. *The World We Live In.* Musson Book Co.

ONTARIO, DEPARTMENT OF MINES. *Our Mineral Heritage.* Toronto: Parliament Buildings.

SHAW, MARGARET MASON. *Geologists and Prospectors.* Clarke, Irwin & Co., Ltd.

SHELL OIL COMPANY. *The Story of Petroleum.* (Available from the Shell Oil Company, Box 400, Terminal A, Toronto.)

TYRRELL, G. W. *The Earth and Its Mysteries.* Clarke, Irwin & Co. Ltd.

II: THE SOIL

AMERICAN SOCIETY OF AGRONOMY. *Hunger Signs in Crops.* Washington, D.C.

BENNETT, HUGH HAMMOND. *Elements of Soil Conservation.* McGraw-Hill Co. of Canada, Ltd.

BROMFIELD, LOUIS. *Malabar Farm.* Musson Book Co., Ltd.

BROMFIELD, LOUIS. *Pleasant Valley.* Musson Book Co., Ltd.

KELLOGG, CHARLES E. *The Soils That Support Us.* Collier-Macmillan (Canada), Ltd.

KILANDER, HOLGER F. *Nutrition for Health.* McGraw-Hill Co. of Canada, Ltd.

MILLAR, C. E., *et al. Fundamentals of Soil Science.* General Publishing Co., Ltd.

OSBORN, FAIRFIELD. *Our Plundered Planet.* Little, Brown and Co. (Canada), Ltd.

III: WATER

CARSON, RACHAEL L. *The Sea Around Us.* Oxford University Press.

CATHCART, ARTHUR H. *Water or Your Life.* McClelland and Stewart, Ltd.

CULLEN, ALLAN H. *Rivers in Harness: The Story of Dams.* Ambassador Books, Ltd.

ERRINGTON, PAUL L. *Of Men and Marshes.* Collier-Macmillan (Canada), Ltd.

KING, THOMSON. *Water, The Miracle of Nature.* Collier-Macmillan (Canada), Ltd.

IV: THE FOREST

BRUERE, MARTHA BENSLEY. *Your Forests.* McClelland and Stewart Ltd.

CANADA, DEPARTMENT OF FORESTRY. *The Native Trees of Canada.* Ottawa: Queen's Printer.

KELLER, W. PHILIP. *Canada's Wild Glory.* Nelson, Foster and Scott, Ltd.

ONTARIO, DEPARTMENT OF LANDS AND FORESTS. *Systems of Forest Cropping.* Toronto: Parliament Buildings.

V: MAN AND NATURE

BODSWORTH, FRED. *The Last of the Curlews.* Dodd Mead and Co. (Canada), Ltd.

BROWN, HARRISON. *The Challenge of Man's Future.* The Macmillan Co. of Canada, Ltd.

CARSON, RACHAEL L. *Silent Spring.* Thomas Allen, Ltd.

FOX, W. SHERWOOD. *The Bruce Beckons.* University of Toronto Press. (Excellent account of passenger pigeon.)

VOGT, WILLIAM. *The Road to Survival.* George J. McLeod, Ltd.

WOODBURY, DAVID O. *Atoms for Peace.* Dodd Mead and Co. (Canada), Ltd.

Films

National Film Board films may be borrowed from three main sources: from your community film library, from provincial film libraries, and from the Canadian Film Institute, 1762 Carling Avenue, Ottawa. The service charges of these non-profit libraries are nominal. Moving-picture projectors are also available.

I: THE EARTH

Riches of the Earth
Time and Terrain
Struggle for Oil
The Face of the High Arctic
The Precambrian Shield
Iron from the North
The Modern Prospector
Physical Regions of Canada

II: THE SOIL

The World at Your Feet
World in a Marsh

Farm Calendar
Agronomy
Grassland Farming
Western Wheat
Grasshopper Forecast
The Son

III: WATER

Water for the Prairies
Dykes for Dry Land
Trappers of the Sea
Fishing Across Canada
The Salmon's Struggle for Existence
Red Runs the Fraser
The Atlantic Salmon
The Spawning of a Fish
Oyster Man

IV: THE FOREST

The Changing Forest
Trees Are a Crop
Look to the Forest
Treasure of the Forest
Pulp and Paper from Canada
Wood and Wealth
The Forest Tent Caterpillar
Sawflies
Life in the Woodlot
Forest Fire Suppression

V: MAN AND NATURE

Let's Look at Water
One Day's Poison
Safety on the Water
How Safe Are You at Home?
How Do You Drive?
Profile of a Problem Drinker
Call It Rehabilitation
Poison, Pests and People
Interview with Linus Pauling
Atomic Energy in Canada
5BX Plan for Physical Fitness

To The Teacher

Modern usage has tended to give too restricted a meaning to the word "conservation". It is usually thought of in the strictly biological sense as applying to the preservation of wild-life, forest, soil, and water. It means much more than this. Conservation is the conscientious, scientific management of *every resource* which is under our control; thus the highest form of conservation is the conservation and development of the resources which are within ourselves and which determine the use we make of our environmental resources. In short, education is the highest form of conservation, and conservation in all its forms is an educational problem.

Of course the biologist, the agriculturist, and the engineer have important parts to play in the conservation of our natural resources, but the strategic role is that of the teacher, for in the final analysis it is not the technical but the human problems that make conservation necessary. Farms are often run down because of ignorance or apathy. Game is usually depleted because of human greed and destructiveness, and water continues to be seriously polluted because of social inertia or complacency.

In a democracy the success of any programme depends largely upon the widespread realization of the need for it. Some instruction in conservation should therefore be given to all students so that when they reach adulthood they will be aware of the need for remedial measures and will understand the procedures necessary to bring them about.

We must help our students to see something of the magnitude and complexity of the problem. They should come to realize that our renewable natural resources form a delicately balanced system in which all parts are interdependent, and that we cannot upset one factor without causing widespread repercussions in unsuspected places.

For many years we have been brutally and thoughtlessly upsetting the balance of nature, and we have only recently made inadequate and half-hearted attempts at readjustment. We are constantly in danger of upsetting nature's balance by the decimation or extinction of the most desirable types of game and fish. Law enforcement alone does not suffice to curb our tendency to kill too much. We must enlist the help of the teacher to inculcate in the younger generation a sense of responsibility for the living things so completely at their mercy. However, the most serious way in which we disrupt the "web of life" is not by shooting and angling but by the drastic changes we make in the natural environment. We cut down (or burn) forests, we build dams which obstruct the migration of fish, we drain marshes and even lakes, and into other lakes and rivers we pour untreated domestic and industrial wastes. Much of this may be a necessary part of what we confidently call the progress of civilization, but there are many cases in which it is inadvisable and short-sighted.

When a situation becomes so desperate that it demands attention, we are usually satisfied to treat the symptoms rather than to try to discover and correct the fundamental causes. Soil conservation, water power, flood control, erosion, wild-life management, fisheries, and silvaculture cannot be dealt with as self-contained entities, but must be seen as interwoven threads of a complex tapestry. We must learn to think in larger units of time and space. Short-term expediency and sporadic attempts at improvement should be replaced by long-term plans based on large topographical units. In this connection, the establishment of river-valley authorities is a very important step forward, and here again it is evident that the main problems are those relating to human co-operation: problems of raising money and acquiring land, of overlapping jurisdictions, and many others. The students of today will have to deal with these problems a few years hence, and to do so intelligently they must be helped toward an understanding of the meaning and philosophy of conservation. Teachers can do a great deal to develop attitudes of responsibility and self-discipline and to replace the old spendthrift philosophy with the idea of management and wise use.

When teaching conservation we should not restrict its scope to "the conservation of our renewable natural resources". Surely our non-renewable natural resources, and above all our human resources, are worthy of inclusion in any comprehensive study of conservation.

Conservation should be taught, not as a formal course added to an already crowded curriculum, but as a philosophy which permeates all teaching and which will emphasize the development of permanent attitudes rather than the temporary acquisition of facts.

It is hoped that this book will provide both teachers and pupils with

useful material to use in conjunction with the study of science, geography, history, English, and civics, and for enrichment programmes and supplementary reading. There is no doubt that some of the words used in the text are beyond the average vocabulary of the younger students who may use this book. I make no apology for this as it provides an excellent opportunity for a programme of vocabulary enrichment. It would be a valuable exercise to have students compile a list of new words with their meanings at the end of each chapter.

The questions and assignments are designed to increase the pupil's comprehension, to stimulate him to further reading, and to assist him towards the formulation of his own conclusions.

Relating Conservation to the Curriculum

SOCIAL STUDIES

History

History is replete with examples of what happens to lands, and the civilizations they support, when little thought is given to conservation. Students should be encouraged to look back beyond the immediate causes of wars, revolutions, and political upheavals to discover the basic disharmony between man and his environment which brought them about. We are apt to be satisfied with the statement that the Babylonian Empire was destroyed by the Persians when we should be more concerned with the internal destruction caused by neglect and the mismanagement of the human and natural resources. The "handwriting on the wall" was plain to the wise before the Persians attacked. William Vogt says in his *Road to Survival,* "The goat and the axe, driving sands down to the coast, were far more destructive weapons than the horses and javelins of the conqueror Cyrus." The city of Ur, once a famous seaport, now lies in the heart of a desert 150 miles from the sea. The history teacher will be aware of innumerable examples which teach the same fundamental lesson. The following are a few suggestions.

1. The ancient cities of North Africa and North Syria once supported by

rich farmlands; e.g., Carthage and its environs at the time of Hannibal. Are its past glories likely to revive? Its present condition.

2. India, China, Japan and Java. Relationship of population to the carrying capacity of the land. Effect of contact with Western civilization; e.g., medicine and sanitation, agricultural implements. The idea of sustained yield versus extractive farming.
3. Great Britain and Europe. The Industrial Revolution's drawing upon the resources (chiefly topsoil) of newly colonized lands – heavy industries – large populations – social and economic pressures – world wars.
4. The end of colonization. The illusion of limitless resources. Thomas Malthus's theory of population growth.
5. The settlement and development of the "Dust Bowl" region of the U.S. The tobacco lands of Virginia. The cotton lands of the South. The Mississippi floods.
6. The history of the Canadian prairies from the advent of Laurier's immigration policy to the present.
7. The Four Freedoms. How can freedom from want be achieved? Would this help to ensure the other freedoms?

The world population in 1840 was 1 billion; in 1940 it was 2 billion, 200 million. It is estimated that 100,000,000 people have starved in China in the last 100 years. At the time of Admiral Perry Japan had a population of 26,000,000; by 1940 it was 76,000,000.

Ref.: "Lessons from the Old World to the Americas in Land Use." *Report of the Smithsonian Institution,* Washington, D.C.

Geography

The study of geography, particularly of commercial geography, is an ideal medium for the teaching of conservation. In dealing with figures on production and distribution of various resources students should get the habit of questioning, "How long can this go on?", "Is it being used wisely?", "Is it being produced on a basis of sustained yield?", etc. For example, is the destruction of forests for the production of pulp magazines, comics, and "tabloid" newspapers justified? If the exports of a certain product are steadily increasing, is the country becoming richer?

1. Living standards and population trends of various countries should be studied in relation to their resources.
2. Two opposing trends should be made clear. Every acre has a definite carrying capacity: this capacity is decreasing while the demand is increasing.
3. The formation of canyons and deltas.* Reference should be made to the great muddy rivers and the wealth they carry away. How the Yellow River got its name. The Mississippi.

* It takes 1,000 years to form one inch of topsoil. It may be washed away in one torrential rain.

4. The worn-out lands of Asia and Latin America. Formation and classification of soils. Loess formations.
5. El Salvador. A miniature of what the world situation might become.
6. Modern experiments in rehabilitation. T.V.A. Ground-nut experiment in Africa. Local examples of reforestation, etc.
7. Study map of your locality showing land classification for use. Land suited for forest only should not be cleared. Land suited for grazing only should not be ploughed.

ENGLISH

Conservation may be incorporated into the teaching of English in many ways of which the following may serve as examples:

1. Following a nature hike or holiday tour, students might be asked to write an essay on their observations relating to the subject of conservation.
2. One of the essays listed for examination in composition might deal with the importance of natural resources and their conservation.
3. Conservation, or some phase of it dealing with local conditions, might be given as a choice for oral composition or for oratorical contests.
4. Some well written books on conservation might be included in the list which would be accepted for supplementary reading.
5. Reference to the subject might occasionally be made in the teaching of poetry and literature; e.g., Shelley, "Ozymandias":

   " 'Look on my works, ye Mighty, and despair!'
   Nothing beside remains. . . ."

   The Rubaiyat of Omar Khayyam:

   "They say the Lion and the Lizard keep
   The Courts where Jamshyd gloried and drank deep."

MATHEMATICS

Innumerable mathematical examples may be devised by an interested teacher to illustrate important aspects of conservation. The sections in the Canada Year Book and *Canada* dealing with Agriculture, Forestry, Water Power, Mineral resources, etc., provide a factual basis for any type of problem the instructor wishes to design. Merely reading the question will convey to the student some important fact, and completing the problem will increase the significance of the information supplied. In some cases essential facts may be deliberately omitted and a reference given to a book on conservation where the information may be found. This will encourage students to become familiar with interesting literature on the subject. The following are a few suggestions:

1. Canada has 1,290,960 square miles of forest. What percentage of the total land area is this?
2. About 766,000 square miles of Canada's forest are productive; the re-

mainder consists of scrub and stunted trees. The area of productive forest *accessible* under present transportation conditions is about 430,000 square miles. Devise a suitable bar graph illustrating (a) total land area, (b) area covered by forest, (c) area of productive forest, and (d) area of productive forest now accessible.

3. The accessible forests of Canada contain about 55 billion cubic feet of useful timber. What is the average number of cubic feet per square mile? per acre?
4. A cord of wood has the dimensions 4′ x 4′ x 8′. In a well piled cord of unbarked sticks approximately 70% of the over-all volume is solid wood. What volume of solid wood is contained in a cord?
5. During the 10 years 1930-9, fires destroyed an average of 400 million cubic feet of wood per year. Express this in cords. What percentage of the accessible timber is this? Express the destruction in square miles and in acres.
6. During the same period insects and disease destroyed 700 million cubic feet per year. What percentage of the accessible timber is this? Express the result as above.
7. Plot a graph to show the increase of population in Canada from 1900 to the present. See "Vital Statistics" in the Canada Year Book.
8. The corn crop of the U.S.A. uses 3,000,000 tons of plant food per year. This is only 4.7% of the amount of dissolved plant food carried annually to the sea by rivers. What weight of dissolved plant food is annually leached away?
9. A river in flood was found to contain 30 parts per million (p.p.m.) of solids. The rate of flow was 25,000 cubic feet per second (c.f.s.). How many tons of topsoil are being carried away per hour? At this rate how long would it take to remove 6 inches of topsoil from a 100-acre farm? Take 1 cubic foot soil as weighing 80 lbs. (Point out the combined significance of questions 7, 8, and 9.)
10. A female potato beetle produces an average of 500 eggs. If half these are male and half female, how many descendants would a single pair of beetles have at the end of 3 years?
11. If none died, one pair of meadow mice would have 1,000,000 descendants at the end of a year. How many would there be at the end of 2 years? A single mouse consumes about 20 lbs. of grass per year. How many tons of grass would be necessary to support this population? (Are hawks and owls of any value?)

LANGUAGES

French

A considerable literature on conservation can be found in the French language. French teachers should be on the look-out for suitable passages which would serve the dual purpose of giving instruction in the language and, at the same time, emphasizing the importance of some phase of con-

servation. Such passages might be used for regular assignments, for sight work, or for examination purposes.

Les Arbres du Québec. (Comment les identifier facilement)

La Forêt ne doit pas servir de pâturage.

Les Maladies de l'érable à sucre et leur prévention.

L'aménagement de l'érablière. (Ministère des Terres et Forêts, Québec.)

Le Boisé de la Ferme. (Le service de librairie de l'U.C.C., 515 avenue Viger, Montréal.)

Forêts de Communauté. (Association des Ingénieurs Forestiers de la province de Québec.)

Excellents feuillets miméographiés, préparés par le bureau de Renseignements forestiers du ministère des Terres et Forêts de Québec, sont les suivants:

La récolte forestière de la ferme.
Services que se rendent l'agriculture et l'industrie de la pulpe et du papier.
Quelques directives générales pour la terre à bois.
Capital et intérêt.
Brise-vent à l'érablière.
Situation de la section boisée de la ferme.
Inspectez vos pins blancs.
Observons la loi.
Egouttement.
Quelques termes sylvicoles.
Elagage artificiel.

Latin

In the study of Latin opportunities may occasionally arise where a brief reference to conservation would be appropriate. The following may serve as suggestions:

1. The derivation of the word: *servo* and *conservo*. Is the literal meaning the best one to be applied to our natural resources? Is it synonymous with hoarding? The idea of *wise use*.
2. In the reading of Livy's account of Hannibal's campaigns the ancient power and wealth of Carthage might be contrasted to its present state. Other ancient lands, once rich, now turned to desert.
3. In Catullus's "Inscription for a Yacht" we see how rapidly the forests of the Mediterranean region were cut down without any thought for their replacement.
4. Passages in Horace extolling the simple life of the country-side and describing the best methods of cultivation. In the description of his trip to Brundisium, Horace describes the wasted land of Apulia where a high price is paid for water and the bread is full of sand.

HEALTH

There are many phases of conservation which might profitably be discussed under the heading of Health. Here are a few suggestions:

1. The importance of good food. Its source.

The necessity of soil conservation.
Food from deficient soil may lack essential minerals though appearing wholesome. Hidden hunger.[1]

2. Outdoor recreation. Hunting, fishing, camping, swimming, canoeing, etc. The importance of unspoiled woods and waters.
3. Good drinking-water. Sanitation. Sewage Disposal. The importance of water conservation.
4. Mental Health. Conserving human energy.[2] Good study and work habits.

CHEMISTRY

Under this heading teachers might point out that applied chemistry is essentially the processing and transforming of our natural resources into more convenient and usable forms. In spite of the advances of synthetic chemistry we would be helpless without the raw materials of the fields, forests, and mines. We are dependent upon the chlorophyll of green leaves for our food. The study of chemistry reveals nature's perfect examples of conservation in the carbon cycle, nitrogen cycle, etc. The subject might be introduced in this way and followed up by discussions of such topics as:

1. Elements essential to plant life. How these elements are lost from the soil. The problem of maintaining and increasing soil fertility. Fixation of nitrogen.
2. Chemistry and forest products. The problem of overcutting and the importance of reforestation.
3. The problem of pollution from chemical industries.

Emery, *Chemistry in Everyday Life* (Lyons & Carnahan, New York).
McPherson, *Chemistry at Work* (Ginn & Company, Toronto).
Slosson, *Creative Chemistry* (Century Company, New York).

HOUSEHOLD ECONOMICS

Conservation, or the wise and economic use of materials, has a very definite application to the teaching of household economics. The following are some aspects of the subject which might be touched upon.

1. Conservation of food by avoiding waste and spoilage.
2. Conserving health and money by the wise selection of foods.
3. Conserving nutritional values (vitamins, etc.) by proper methods of cooking and preserving.
4. The source of all food (and clothing). The necessity for soil conserva-

[1] "Good Food is Good Business", Royal Bank of Canada, Montreal.

[2] Christopher Morley expresses the idea very aptly: "We hear about the agricultural problem of soil erosion; hillsides denuded of fertile topsoil, or great regions of the Middle Western richness scoured off by dust storms. Surely not less serious is the matter of mind erosion; the dust storms of daily excitement and of continual triviality can easily blow away the sensitive topsoil of the spirit. The result is a barren and shallow nervous credulity."

tion. Food from deficient soil may lack essential elements although appearing wholesome. Hidden hunger.

5. Conserving electricity. Well insulated refrigerators and ovens. Use of pressure-cookers. Proper planning to conserve electric power.
6. The source of electricity. The importance of water conservation.
7. What should be done with surplus materials such as waste paper, fat, "tin cans", discarded clothing, and shoes?
8. *Mathematical problems*
   For example: A hot-water tap was left dripping for 24 hours at the rate of 2 gallons per hour. The heater operated on 110-volt circuit and required a current of 60 amp. It heated water to the required temperature at the rate of 2 gallons per hour. Find the cost of the wastage at 5¢ per K.W.H.

SHOP WORK

There are many opportunities for the teaching of conservation in connection with shop work.

1. In studying the properties and uses of the various types of wood, students should learn to recognize the commoner native trees. This should lead to a discussion of forest conservation.
2. In connection with metals and alloys, students should know something of the minerals from which they are obtained. This should lead to a discussion of the wise use of our mineral resources. The importance of conserving scrap metal.
3. The indispensability of electricity in modern industry. The source of electric power. Water conservation.
4. Conservation of the fuels which give machines their energy – coal, wood, petroleum, gas.
5. Conservation of human energy, time, and materials by proper organization and planning.
6. *Mathematical problems*
   For example: In Canada forest fires have destroyed as much as 400 million cubic feet of lumber per year. How many 6-roomed houses could have been built from this lumber if each house required 5,000 board feet?

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